REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR SITES FTIR-38 AND FTIR-40

FINAL

NATIONAL TRAINING CENTER
FORT IRWIN, CALIFORNIA

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This final report entitled "Remedial Investigation/Feasibility Study" for Sites FTIR-38 and FTIR-40", located at the Fort Irwin National Training Center, California, was prepared under the direction of the U.S. Army Corps of Engineers, Sacramento District (USACE). The following key project staff with the USACE and MWH provided technical leadership and review.

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REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR SITES FTIR-38 and FTIR-40

FORT IRWIN NATIONAL TRAINING CENTER

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celcius
°F	degrees Fahrenheit
%D	percent difference
%RSD	percent relative standard deviation
ABS	absorption fraction
AF	adherence factor
APCL	Applied Physics and Chemistry Laboratory
APPL	Agriculture and Priority Pollutant Laboratories
ARAR	Applicable or Relevant and Appropriate Requirements
ASTM	American Society of Test Methods
ATSDR	Agency for Toxic Substance and Disease Registry
bgs	Below Ground Surface
BTAG	Biological Toxicological Advisory Group
BTEX	benzene, toluene, ethylbenzene, xylenes
BUTL	background upper tolerance limits
BW	body weight
CAA	Clear Air Act
Cal-EPA	California Environmental Protection Agency
Cal-OSHA	California Occupational Safety and Health Administration
CAMU	corrective action management units
CCR	California Code of Regulations
CDAP	Chemical Data Acquisition Plan
CDFG	California Department of Fish and Game
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm^2	square centimeters per day
COC	constituent of concern
COEC	chemical of ecological concern
COPC	Chemicals of Potential Concern
COPEC	Chemicals of Potential Ecological Concern
CSC	California Species of Special Concern
CSF	cancer slope factor
CSM	conceptual site model
CX	Center of Expertise
DHS	Department of Health Services
DQO	Data Quality Objectives
DTSC	Department of Toxic Substances Control
ECAO	Environmental Criteria Assessment Office
ED	exposure duration
EDXRF	energy dispersive x-ray fluorescence
ELAP	Environmental Laboratory Accreditation Program
EPC	exposure point concentration
ERA	ecological risk assessment

ACRONYMS AND ABBREVIATIONS
(Continued)

ESA	Endangered Species Act
ESMP	Endangered Species Management Plan
FORSCOM	U.S. Army Forces Command
FS	Feasibility Study
Goldstone	Goldstone Deep Space Communications Complex
GRA	general response action
HEAST	Health Effects Assessment Summary Tables
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
ICP	inductively coupled plasma spectorscopy
ILCR	incremental lifetime cancer risk
IR	igestion rate
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
K_d	soil/water distribution coefficient
kg	kilogrrams
L/g	liters per gram
LCS	laboratory control samples
LDR	land disposal restrictions
LOAEL	lowest-observed-adverse-effects
MAAR	Mojave Anti-Aircraft Range
MDL	method detection limit
m^3	cubic meters
μg/dl	micrograms per deciliter
μg/kg	micrograms per kilogram
$\mu g/m^3$	microgram per cubic meter
mg	milligram
mg/day	milligrams per day
mg/kg	milligrams per kilograms
mg/kg-day	milligrams per kilogram per day
mm	millimeters
MS/MSD	matrix spike/matrix spike duplicates
MWH	MWH Americas, Inc.
NAAQS	National Primary and Secondary Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	non-detect values
NHPA	National Historic Preservation Act
NOAEL	no-observable-adverse-effect-level
NRC	National Research Council
NIC	National Training Center
O&M	operation and maintenance

ACRONYMS AND ABBREVIATIONS
(Continued)

Onsite	Onsite Environmental Laboratories
OSWER	Office of Solid Waste Management and Emergency Response
PAH	Polyaromatic Hydrocarbons
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCB	polychlorinated biphenyl
PM	project manager
PMP	Programmatic Management Plan
PRG	preliminary remediation goals
QA	quality assurance
QC	quality control
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RDA	recommended daily allowance
RfD	reference dose
RI	Remedial Investigation
RL	reporting limits
RPD	relative percent difference
SARA	Superfund Amendments and Reauthorization Act
SBAQMD	San Bernardino Air Quality Management District
SI	Site Inspection
SOP	standard operating procedure
SSA	skin surface area
SSCL	site specific cleanup levels
SSL	Soil Screening Levels
STLC	soluble threshold leaching concentration
SUF	site utilization factor
SVOC	semivolatile organic compound
TBC	To Be Considered
TCLP	toxicity characteristic leaching procedure
TEF	toxicity equivalency factors
TMV	Toxicity, Mobility, or Volume
TPH	total petroleum hydrocarbons
TRPH	total recoverable petroleum hydrocarbons
TRV	toxicity reference values
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UXB	UXB International, Inc.
UXO	unexploded ordinance

ACRONYMS AND ABBREVIATIONS
(Continued)

VOC	Volatile Organic Compound
XRF	X-ray fluorescence

EXECUTIVE SUMMARY

The United States Army Corps of Engineers, Sacramento District (USACE) contracted MWH Americas, Inc. (MWH) to conduct a Remedial Investigation (RI) and a Feasibility Study (FS) for Sites FTIR-38 and FTIR-40 at the National Training Center (NTC), Fort Irwin and at the Goldstone Deep Space Communications Complex (Goldstone).

Fort Irwin encompasses an area of approximately 1,000 square miles in the Mojave Desert in San Bernardino County, California. The community of Barstow is located approximately 35 miles southwest of the installation. Site FTIR-38, Goldstone Lake Mortar/Small Arms Range, is located in the Goldstone Dry Lake Playa in the western portion of Fort Irwin. The site consists of two subsites, Area 1 and Area 2. Area 1 was apparently used as a target for firearms and mortar. Area 2 consists of 18 soil berms that were used as backstops for target practice. Site FTIR-40, Mojave Anti-Aircraft Range, is located on the western edge of the Goldstone Dry Lake alluvial basin, approximately 4 miles southwest of Site FTIR-38. Site FTIR-40 is divided into two major subsites, Area 1 and Area 2. Area 1 consists of a wash which contains two sub-areas (Area 1.1 and Area 1.2) that contain discarded metal debris and artillery rounds. Area 2 is east of Area 1 and consists of several derelict foundation slabs and a sump that may have been a septic tank.

During the Site Investigation in June 1997, Montgomery Watson conducted site inspection activities to characterize soil impacts at Sites FTIR-38 and FTIR-40. Results of surface soil samples collected from Area 1 and Area 2 at Site FTIR-38 suggest that several metals are present above background levels. For Site FTIR-40, total recoverable petroleum hydrocarbons and numerous metals were detected at concentrations above background levels in soil samples collected from Area 1.1 and from a test pit excavation in the vicinity of the septic tank at Area 2. Based on the results of the screening level human health and the Phase I Ecological Risk Assessment (ERA) in the Site Investigation Report (Montgomery Watson, 1998), further evaluation of the human health and ecological risks at Site FTIR-38 Area 2 and Site FTIR-40 Areas 1.1 and 2 was necessary.

During May 1999, Montgomery Watson performed remedial investigation activities at Sites FTIR-38 and FTIR-40 to further characterize the nature and extent of soil impacts to support the baseline human health and ecological risk assessments. The field activities consisted of the following:

- Unexploded ordinance (UXO) avoidance at Sites FTIR-38 and FTIR-40
- Plant tissue and surface soil sampling at Sites FTIR-38 Area 2, FTIR-40 Area 1.1, and FTIR-40 Area 2 and two reference areas adjacent to FTIR-38 and FTIR-40
- Drilling soil borings and subsurface soil sampling in the vicinity of the septic tank and suspected leachfield at Site FTIR-40 Area 2
- X-ray fluorescence sampling (XRF) for lead at Site FTIR-38 Area 2

In addition, the USACE collected subsurface soil samples from Site FTIR-38 Area 1 to determine the vertical extent of metal contamination at this site. The subsurface soil analytical data reported several metals, including calcium, lead, and zinc above background concentrations established for surface soils at Fort Irwin.

Results from the surface soil samples and XRF analyses for Site FTIR-38 Area 2 indicate that lead is the primary contaminant of concern at this site. The highest concentrations of lead (exceeding 1000 milligrams per kilogram [mg/kg]) were detected in four of the southwest soil berms. Concentrations of lead were observed to be the highest in the surface six inches of soil at the center of each berm in FTIR-38 Area 2 soils. Lead concentrations decreased laterally from the center of the berm and with soil depth. Additionally, aluminum, barium, copper, and zinc were reported at concentrations slightly above background levels in the surface soil samples from Site FTIR-38 Area 2.

Results of the surface soil samples collected from Site FTIR-40 Area 1.1 indicated that concentrations of metals (lead, zinc, copper, and barium) exceeded background adjacent to areas with metallic debris. Analysis of subsurface soil samples collected from five soil borings in the suspected leachfield at Site FTIR- 40 Area 2 revealed high levels of nitrate and low levels of bis(2-ethylhexyl)phthalate adjacent to the septic tank. Slightly elevated concentrations of arsenic, calcium, lead, and manganese, which exceed background levels, were also detected in both surface and subsurface soil samples in this area.

In addition to the remedial investigations, Montgomery Watson conducted well abandonment activities at Goldstone Well A located at Site FTIR-40 Area 2 in December 1998. Goldstone Well A was abandoned by pressure grouting the well with neat cement.

A baseline human health risk assessment (HHRA) was conducted for Sites FTIR-38 (Area 1 and Area 2) and FTIR-40 (Area 1.1 and Area 2) based on exceedences of screening risk criteria in the Site Investigation Report (Montgomery Watson, 1998). The results of the baseline HHRA for Sites FTIR-38 Area 1 and FTIR-40 Area 2 indicated that the total cumulative cancer risk and noncancer hazard estimates for hypothetical future residents and industrial workers are within the United States Environmental Protection Agency's (USEPA) risk management ranges at these sites. Therefore, Sites FTIR-38 Area 1 and FTIR-40 Area 2 are recommended for no further action in regard to human health concerns. At Sites FTIR-38 Area 2 and FTIR-40 Area 1.1, lead concentrations in surface soil exceeded acceptable risk criteria, and lead was retained as a constituent of concern (COC) for further evaluation. Lead was the only COC identified by the HHRA that required further analysis in the FS.

For the ERA, the Phase II Ecological Validation Study was initiated because hazard indices (HI) in excess of 1.0 for the Mojave ground squirrel were identified during the Phase I quantitative portion of the screening ERA for Sites FTIR-38 and FTIR-40 (Montgomery Watson, 1998). At the request of the Department of Toxic Substances Control (DTSC), the Army conducted plant tissue sampling in April 1999 to be used in the validation of exposure dose estimates for the Mojave ground squirrel. Thus, plant tissue data collected from Sites FTIR-38 and FTIR-40, in conjunction with co-located soils data and site-specific reference data, were evaluated in this Phase II Ecological Validation Study.

The Phase I ERA identified potential risks to the Mojave ground squirrel from eight metals in FTIR-38 soils including: aluminum, antimony, arsenic, barium, cobalt, copper, lead, and zinc. Following the Phase II Ecological Validation Study, only aluminum and lead were retained as potential chemical of ecological concern (COECs) for consideration in the FS. The Phase I ERA identified potential risks to the Mojave ground squirrel from fourteen metals at Site FTIR-40 Area 1.1 included: aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, nickel, selenium, silver and zinc. The Phase II Validation Study indicated that cadmium, copper, lead and zinc should be retained as potential COECs for consideration in the FS. The Phase I ERA identified potential risks to the Mojave ground squirrel from four metals at Site FTIR-40 Area 2 included: arsenic, cadmium, lead, and zinc. The Phase II Ecological Validation Study demonstrated that only lead was retained as a potential COEC for consideration in the FS.

Section 8.0 presents the potentially applicable or relevant and appropriate requirements (ARARs) and remedial action objectives (RAOs) for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1. Other portions of Site FTIR-38 and FTIR-40 have been eliminated from further consideration because they do not pose a human health or ecological risk for any constituent based on the results of the RI and the analysis conducted in HHRA and ERA. Surface soils were the only media identified as being potentially impacted. Other media were either not present (surface water, sediment) or were not impacted (groundwater, subsurface soil, air), and not carried through to the FS.

The RAOs and site specific cleanup levels for surface soils in Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 are based on industrial land use as the Deep Space Satellite Tracking Station operated by NASA, and as habitat for indigenous wildlife. RAOs are to:

- Prevent direct contact (i.e., ingestion, dermal contact, and inhalation exposure) of industrial workers to COCs in surface soils (0 to 1 foot) in excess of site specific cleanup goals.
- Prevent direct contact (i.e., ingestion of impacted plants, dermal contact, and incidental soil ingestion) by ecological receptors to concentrations of COECs in excess of site-specific cleanup goals for surface soil (0 to 3.5 feet).

Site specific cleanup levels (SSCL) were developed for surface soils for human health, ecological risks, background conditions, ARARs and to be considered (TBCs) discussed in Sections 8.1 and 8.2. The HHRA (Section 6.0) identified lead in surface soil (0 to 1 foot), as the only COC that required further evaluation in the FS based on the industrial land use scenario. Subsurface soils (below 1 foot) were evaluated but did not exceed risk based action criteria for industrial land use.

The Phase II Validation Study (Section 7.0) identified five potential COECs in surface soils (0 to 3 feet), including lead, aluminum, copper, cadmium and zinc. To further refine potential COECs, Region 9 PRGs, Soil Screening Levels (SSLs), background upper tolerance limits (BUTLs) for Fort Irwin soils, and risks based on Biological Toxicological Advisory Group (BTAG) low toxicity reference values (TRVs), BTAG high TRVs, and Army TRVs were evaluated. Based on these criteria (summarized in Table 8-1), the Army TRVs were selected as the criteria upon which final COECs would be selected because risks based on Army TRVs fell in between those calculated using BTAG low and BTAG high TRVs, but still favored a minimal level of potential effects. On this basis, lead, copper, and aluminum were retained as COECs, with cadmium and zinc eliminated from further consideration.

Three remedial alternatives were identified for Site 38 Area 2 and five alternatives were identified for Site 40 Area 1.1. The alternatives range from no action to clean closure. The alternatives were evaluated against nine criteria specified by the USEPA. These nine criteria include overall protection of human health, ecological receptors, and the environment; compliance with ARARs and RAOs; long-term effectiveness; reduction of toxicity, mobility, and volume (TMV); short-term effectiveness; implementability; cost; and community and state acceptance.

Site FTIR-38 Area 2. The three alternatives identified for Site FTIR-38 Area 2 include no action (Alternative 1), institutional controls (Alternative 2), and limited soil removal and disposal (Alternative 3). A detailed analysis of clean closure was not developed for Site FTIR-38 Area 2 because of the habitat destruction over such an extensive area that would be required. Alternatives 1 and 2 are protective of human health under the current (casual visitor) and most probable future land use (industrial worker) conditions. The no action alternative does not meet the intent of the ARARs or RAOs. Institutional controls meet the intent of most ARARs but do not meet RAOs. Alternative 3 meets the intent of all ARARs and achieves RAOs. The present values of Alternatives 1, 2, and 3 are estimated to be \$7,000, \$113,000, and \$440,000, respectively. The preferred alternative for Site FTIR-38 Area 2 is Excavation and Soil Removal to RAOs, because it is protective of human health, ecological receptors, and the environment under current and future land use conditions and meets the intent of all ARARs and achieves RAOs.

Site FTIR-40 Area 1.1. The five alternatives identified for Site FTIR-40 Area 1.1 include no action (Alternative 1), institutional controls (Alternative 2), surface debris removal with institutional controls (Alternative 3), limited soil removal followed by construction of a soil cover (Alternative 4), and clean closure (Alternative 5). The no action alternative (Alternative 1) does not meet the intent of the ARARs nor RAOs. Institutional controls (Alternative 2) and surface debris removal with institutional controls (Alternative 3) meet the intent of most ARARs but does not meet RAOs. The remaining two alternatives meet the intent of the ARARs and achieve RAOs.

The present-value of Alternatives 1, 2, and 3 for Site FTIR-40 Area 1.1 are estimated to be \$7,000, \$108,000 and \$152,000, respectively. The present-value of Alternative 4 and Alternative 5 is \$488,000 and \$902,802, respectively. Alternative 4 is the preferred alternative because it is equally protective of human health and ecological receptors, compared to Alternative 5 under current and future land use conditions, meets the intent of ARARs, achieves RAOs, and is more cost effective than Alternative 5.

1.0 INTRODUCTION

MWH Americas, Inc. (MWH) was contracted by the United States Army Corps of Engineers (USACE), Sacramento District to conduct a Remedial Investigation (RI) and a Feasibility Study (FS) for Sites FTIR-38 and FTIR-40 at the National Training Center (NTC), Fort Irwin. The RI and FS were authorized under Delivery Order 37 and Task Order 08 for Contract Nos. DACW05-95-D-0023 and DACW05-98-D-0033, respectively.

Site investigations and screening level risk assessments were previously conducted at Sites FTIR-38 and FTIR-40 as part of a Site Inspection (SI) under Delivery Order 25 (Montgomery Watson, 1998). Additional investigations of Sites FTIR-38 and FTIR-40, including Phase II ecological validation studies, were recommended by the California Department of Toxic Substances Control (DTSC) and agreed to by the Army. The additional investigation methods were described in the Workplan for Sites FTIR-32A, FTIR-38, FTIR-39, and FTIR-40 (Montgomery Watson, 1999). The additional investigations for Sites FTIR-32A and FTIR-39 were completed and documented in the Final RI for Sites FTIR-32A and FTIR-39 (Montgomery Watson, 2001).

1.1 OBJECTIVES

Based on the results of the screening level human and ecological risk assessments in the SI report (Montgomery Watson, 1998), a RI was recommended to further characterize the extent of metal contamination in the soils at Sites FTIR-38 and FTIR-40. It was also determined necessary to further evaluate the human health and ecological risks at these sites. Specific objectives for each sub-site at Sites FTIR-38 and FTIR-40 are outlined in the following subsections.

1.1.1 Remedial Investigation

The RI report for Sites FTIR-38 and FTIR-40 includes a baseline human health risk assessment (HHRA) and a Phase II ecological validation study. The objectives of this RI report are described below and are summarized in Table 1-1.

- Site FTIR-38 Area 1. Determine the vertical extent of metal contamination at Area 1 based on the soil sampling analytical results collected at 2 and 5 feet below ground surface (bgs) by USACE in 1998. Evaluate the baseline HHRA using available soil data. No further ecological risk evaluation will be conducted based on the lack of habitat documented in the SI.
- Site FTIR-38 Area 2. Delineate the nature and extent of lead contamination at Area 2. Evaluate the baseline HHRA using the available soil data from previous and current investigations. Perform a Phase II ecological validation study based on the analytical results of soil and plant tissue sampling.
- Site FTIR-40 Area 1.1. Evaluate the baseline HHRA using available soil data. Perform a Phase II ecological validation study by evaluating the plant tissue samples with respect to the reference area.
- Site FTIR-40 Area 1.2. Based on the findings of the screening level risk assessments in the SI, no further human health or ecological evaluation will be conducted for this site.
- Site FTIR-40 Area 2. Determine the vertical extent of contamination based on the analytical results of the subsurface soil samples collected at depths of 2.5, 5, and 10 feet bgs. Evaluate the baseline HHRA using the available soil data from previous and current investigations. Based on the analytical results of the soil and plant tissue sampling, perform a Phase II ecological validation study.

1.1.2 Feasibility Study

Based on the results of the RI, Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 were considered further in the FS portion of this report. The objective of the FS is to evaluate potential remedies that encompass a range of appropriate options by developing, screening, and analyzing remedial alternatives for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1. The ultimate goal of this effort is to provide a rational basis for the selection, and subsequent implementation of a cost-effective remedial alternative that assures the protection of human health and the environment.

1.2 SITE LOCATION

Fort Irwin encompasses an area of approximately 1,000 square miles in the Mojave Desert in San Bernardino County, California. The community of Barstow is located approximately 35 miles southwest of the installation (Figure 1-1). Fort Irwin was originally established in 1940 as the

Mojave Anti-Aircraft Range (MAAR) to provide a range where training in the use of anti-aircraft weapons could be conducted without interruption. The California Institute of Technology also used the area around Goldstone Dry Lake for rocket testing. In 1972, the California National Guard assumed operation of the facility. The U.S. Army was reissued command of the facility in 1981, and Fort Irwin became the NTC for the Army. The installation is currently under the command of the U.S. Army Forces Command (FORSCOM).

1.2.1 Site FTIR-38 – Goldstone Lake Mortar/Small Arms Range

Site FTIR-38, also known as the Goldstone Lake Mortar and Small Arms Range, is located in the east-central portion of Goldstone Dry Lake Playa (Figure 1-1). The site can be divided into two major subsites, Area 1 and Area 2 (Figure 1-2). These subsites are described in Sections 2.1.1 and 2.1.2, respectively.

1.2.2 Site FTIR-40 – Mojave Anti-Aircraft Range

Site FTIR-40, also known as the MAAR, is located on the eastern edge of a low range of hills and on the western edge of the Goldstone Dry Lake alluvial basin (Figure 1-1). It is approximately 4 miles southwest of Site FTIR-38. Several building remains (primarily building foundation slabs), comprising a former military outpost, exist at the site. The site has been divided into two subsites (Area 1 and Area 2). Area 1 is further subdivided into Area 1.1 and Area 1.2 (Figure 1-3). Subsites Area 1 and Area 2 are described in Sections 2.1.3 and 2.1.4, respectively.

1.3 REPORT ORGANIZATION

The organization of this report is as follows:

Section 1.0 Introduction

Section 2.0 Site Background

Section 3.0 Investigative Techniques and Data Quality

Section 4.0	Nature and Extent of Site Impacts
Section 5.0	Contaminant Fate and Transport
Section 6.0	Baseline Human Health Risk Assessment
Section 7.0	Phase II Ecological Validation Study
Section 8.0	Applicable Relevant and Appropriate Requirements and Remedial Action Objectives
Section 9.0	Identification and Screening of Remedial Technologies
Section 10.0	Development and Screening of Remedial Alternatives
Section 11.0	Detailed Analysis of Remedial Alternatives
Section 12.0	Remedial Investigation/Feasibility Study Recommendations

The following information is included as appendices to this report:

Appendix A	Responses to Comments
Appendix B	Site Photographs
Appendix C	DTSC Letter Regarding Risk Driving Metals
Appendix D	Plant Tissue Sampling Summary
Appendix E	X-ray fluorescence (XRF) Technical Procedure and Correlation Results
Appendix F	Land Survey Data
Appendix G	Analytical Results
Appendix H	Chain-of-Custody Forms
Appendix I	Data Validation Reports
Appendix J	Field Duplicate and Confirmation Data Summary
Appendix K	Site FTIR-38 Area 2 Soil Sample Locations and Results
Appendix L	Toxicology Profiles
Appendix M	Human Health Risk Assessment Calculations
Appendix N	Surface Soil and Plant Tissue Statistical Comparisons
Appendix O	Descriptions of Applicable Technologies for Soil Remediation
Appendix P	Remedial Alternative Cost Analysis

2.0 SITE BACKGROUND

The following sections provide descriptions of the subsites at Sites FTIR-38 and FTIR-40. Descriptions of the physical characteristics and history of each site were generally excerpted from Parsons ES Workplan (Parsons ES, 1995). A summary of local geology, hydrology, and surface water hydrology is also presented. Additionally, all previous investigations that have been conducted at Sites FTIR-38 and FTIR-40 are also summarized in this section.

2.1 SITE DESCRIPTION

2.1.1 Site FTIR-38 Area 1

Site FTIR-38 Area 1 is characterized by two lines, each approximately 200-feet long, of deteriorated wooden targets that intersect at right angles. Within the right angle formed by the target lines is a 200-foot diameter circle of 55-gallon drums with a pile of tires in the center (Figure 1-2). A large number of small caliber (e.g. 50 caliber, 20 millimeters [mm]) shells and several mortar rounds were strewn around the surface of the site.

2.1.2 Site FTIR-38 Area 2

Site FTIR-38 Area 2 consists of a series of 18 soil embankments on the dry lake bed that were apparently used as backstops for target practice (Figure 1-2). Spent rounds of 20 mm and 50-caliber ammunition were heavily concentrated near these soil embankments. Wooden debris and posts were in front of several of the embankments. These posts, also known as strafing, may have been used to hold the target cloth for airplane target practice. This site may have been used as an airplane shooting range. Photographs of this site are provided in Appendix B.

2.1.3 Site FTIR-40 Area 1

Site FTIR-40 Area 1 consists of a small wash containing discarded metal debris and artillery rounds in two sub-areas (Area 1.1 and Area 1.2), as shown in Figure 1-3. Area 1.2, the western sub-area, consists of scattered small amounts of miscellaneous debris (e.g. asphalt and metal). Area 1.1, the more concentrated main sub-area, consists of a soil mound (approximately 100 feet by 50 feet) that contains municipal solid waste debris and some artillery shells.

2.1.4 Site FTIR-40 Area 2

Site FTIR-40 Area 2 is situated downstream of Area 1.1, on an alluvial fan surface just east of the point where the wash emerges onto the fan (Figure 1-3). Area 2 consists of the foundations of several previously existing buildings and other facilities. An abandoned water well (referred to as Goldstone Well A) is embedded in one of the building foundation slabs. In addition, a sump that may have been a septic tank is located adjacent to one of the foundation slabs (Figure 1-3).

2.2 GEOLOGY, HYDROLOGY, AND SURFACE WATER HYDROLOGY

Site FTIR-38 is underlain by fine-grained, lacustrine sediments Geotechnical soil samples collected from Site FTIR-38 indicated that surface soils at this site consist of silty to sandy clays (Montgomery Watson, 1997) The thickness of alluvial and lacustrine sediments underlying this site is unknown but is expected to exceed several hundred feet, as indicated by the logs of well borings drilled in the vicinity (Parsons ES, 1995). Site FTIR-38 is periodically inundated during rainy periods. Because of the low permeability of the clayey sediments at the surface, much of the standing water that reaches the lake bed evaporates.

Site FTIR-40 Area 1 is located in a small eastward-draining wash, and Site FTIR-40 Area 2 is located on an alluvial fan immediately west of a gully mouth. Both areas are underlain by an unknown thickness of gravelly alluvium. Geotechnical testing indicates that surface soils at Site FTIR-40 consist of silty sand with gravel (Montgomery Watson, 1997). Surface runoff is toward Goldstone Dry Lake Playa.

Two existing inactive wells in the Goldstone area provide hydrogeologic information. Static water levels from 1943 were measured at approximately 170 feet bgs. However, Goldstone Well

A was abandoned in December 1998 to a total depth of 176 feet and no groundwater was encountered (see Section 4.4.3).

2.3 SUMMARY OF PREVIOUS INVESTIGATIONS

An inspection of seven sites at Fort Irwin was conducted in June 1997 to characterize each site, evaluate the potential risks to the environment, and recommend future actions (Montgomery Watson, 1997). A SI Report was completed the following year for four of those sites (FTIR-32A, FTIR-38, FTIR-39, and FTIR-40 (Montgomery Watson, 1998). The SI report assessed the potential risks by conducting screening level human health and ecological risk assessments (ERA). The activities and findings at Sites FTIR-38 and FTIR-40 are included in the following subsections

2.3.1 Site FTIR-38

In June 1997, surface soil samples were collected within the 55-gallon drum circle at Site FTIR-38 Area 1 and analyzed for metals, nitroaromatics/nitroamines, nitrogen-ammonia, nitrate/nitrite, and nitroglycerin Surface soil samples were also collected from the four most visually contaminated berms in Site FTIR-38 Area 2 and analyzed for metals. The surface soil sampling locations are shown in Figure 2-1 Metals, including lead, copper, and zinc, were detected in both areas, as shown in Figure 2-1, and are probably associated with the high percentage of metal debris found at the surface of the site. Further details on the analytical results can be found in the Final Data Summary Report for SI of Seven Sites: FTIR-32A (Lower Goat Mountain Landfill), FTIR-32A (Upper Goat Mountain Diesel Spill), FTIR-32B, FTIR-25E, FTIR-38, FTIR-39, and FTIR-40 (Montgomery Watson, 1997).

The results of the screening level HHRA showed that the generally accepted risk and hazard criteria for future residential land uses were exceeded in both Area 1 and Area 2 of Site FTIR-38. In addition, hazard estimates for Site FTIR-38 Area 2 also exceeded the generally accepted hazard criteria for future industrial land uses (Montgomery Watson, 1998).

No significant ecological habitat is available at Site FTIR-38 Area 1; therefore, quantitative ecological risk characterizations were not performed for this site. However, for Site FTIR-38 Area 2, some potential habitat was identified, and the screening level ERA identified a potential for adverse effects on the Mojave ground squirrel and other consumer species exposed to impacted soils at this site. No ecological impacts to upper trophic level species were anticipated based on the results in the SI for the golden eagle (Montgomery Watson, 1998).

Following the screening level risk assessments, the SI report recommended that a RI be performed to further characterize the vertical and lateral extent of metal contamination in soils at Site FTIR-38 (Montgomery Watson, 1998). In July 1998, the USACE collected two subsurface soil samples from Site FTIR-38 Area 1 to determine the vertical extent of metal contamination. These samples, collected at the location of 38-1-SS-2 (Figure 2-1) at 2 feet bgs and 5 feet bgs, were analyzed for metals. The analytical results are discussed in Section 4.1.2.

2.3.2 Site FTIR-40

In June 1997, surface soil samples were collected in Site FTIR-40 Area 1.1 near a pile of metal debris and near pieces of metal debris in Site FTIR-40 Area 1.2. Soil samples were also collected from a test pit that was excavated within the center of a large pile of debris at Area 1.1. The soil sampling and test pit locations are shown in Figure 2-2. These samples were analyzed for total recoverable petroleum hydrocarbons (TRPH), metals, nitroaromatics/nitoramines, nitrogen-ammonia, nitrate/nitrite, and nitroglycerin. In soil samples collected from Area 1.1, numerous metals were detected above site background upper 95 percent tolerance limits (BUTLs) established for inorganic material in soil ground levels (Parsons ES, 1996). The BUTLs are further discussed in Section 4.0. TRPH was also detected in several samples at a maximum concentration of 180 milligrams per kilogram (mg/kg) in this area. Lead and manganese were detected at concentrations only slightly above BUTLs at Area 1.2; other analytes were either not detected or below BUTLs in this area.

A test pit was excavated to investigate a septic tank in Site FTIR-40 Area 2. The bottom of the septic tank was concrete; therefore, the test pit was moved 3 feet east of the septic tank

(Figure 2-2). During excavation, two pipes were found within the test pit. One pipe led straight down, and the other led east toward the field where numerous depressions were observed at the ground surface. It was hypothesized that this pipe may have led to junction boxes and then out to a leach field. Decomposed wood and discolored soil were also found within the test pit. Soil samples collected from the test pit were analyzed for metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and TRPH. Various metals were detected above BUTLs and TRPH was detected at a maximum concentration of 270 mg/kg. Several SVOCs were detected; benzo(a)anthracene, benzo(a)pyrene, benzo(a)fluoranthene, chrysene, indeno(1,2,3-cd)pyrene, and pyrene were detected at concentrations below the USEPA preliminary remediation goals (PRGs) and concentrations decreased with depth. VOCs were not detected in any of the samples.

The soil sampling analytical results for Site FTIR-40 are summarized in Figure 2-2. Further details on the results can be found in the Final Data Summary Report for SI of Seven Sites: FTIR-32A (Lower Goat Mountain Landfill), FTIR-32A (Upper Goat Mountain Diesel Spill), FTIR-32B, FTIR-25E, FTIR-38, FTIR-39, and FTIR-40 (Montgomery Watson, 1997).

The results of the screening level HHRA (Montgomery Watson, 1998) showed that the risk and hazard criteria for future residential land uses were exceeded in both Area 1.1 and Area 2 of Site FTIR-40. For future industrial land uses, hazard estimates for Site FTIR-40, Area 1.1 exceeded the generally accepted hazard criteria; however, risk and hazard estimates for Site FTIR-40 Area 2 were below the generally accepted hazard criteria (Montgomery Watson, 1998).

The screening level ERA identified a potential ecological adverse impact on desert tortoise populations at both Area 1.1 and Area 2 of Site FTIR-40. However, because potential ecological impacts on the desert tortoise were evaluated based on the hazard estimates for plants and Site FTIR-40 comprises a very small portion of the desert tortoise's home range (i.e., about 1 percent), hazards to the species were considered over-estimated. Therefore, it was considered unlikely the contaminants present in the soils at this site constitute an actual threat to this species. However, a "significant potential" for adverse impacts to the Mojave ground squirrel and other consumer species was identified at Area 1 1 and a "limited potential" for adverse effects on the Mojave ground squirrel was identified at Area 2. Based on the results for the golden eagle, no ecological impacts to upper trophic level species were anticipated (Montgomery Watson, 1998).

Therefore, as discussed in Section 1.0, it was recommended in the SI that a RI be conducted to further characterize the vertical and lateral extent of metal contamination in the soils at Site FTIR- 40 (Montgomery Watson, 1998)

3.0 INVESTIGATIVE TECHNIQUES AND DATA QUALITY

RI activities were conducted during May 1999 at Sites FTIR-38 and FTIR-40 which included unexploded ordinance (UXO) avoidance, plant tissue and soil sampling, drilling soil borings, XRF sampling, and land surveying. The following subsections describe the methodologies and sampling strategies that were used to perform these field activities. A description of laboratory analyses and quality control procedures is also provided in this section. The samples collected are presented in Table 3-1 and the sampling analytical results are described in Section 4.0. Photographs showing some of the site activities are presented in Appendix B.

3.1 UNEXPLODED ORDINANCE AVOIDANCE

UXB International, Inc. (UXB) of Ashburn, Virginia, was contracted by MWH to perform all UXO avoidance field activities. These field activities consisted of surface avoidance of UXO for site walkovers and vehicle access as well as subsurface avoidance of UXO for all intrusive work. UXB performed a visual and magnetometer reconnaissance of each area before MWH conducted the required field activities. Once clear paths were identified, these boundaries were marked. When UXO was encountered on the surface, the area was marked, closed off, and reported immediately to Fort Irwin Range Control.

Prior to drilling each soil boring at Site FTIR-40 Area 2, the UXO team located an area free of magnetic anomalies within a 2-foot sphere of detection. To properly determine if the site was safe beyond the surface level, the boring was advanced to a depth of approximately 2 feet bgs to take a magnetometer reading at this depth. When no magnetic anomalies were detected, drilling was allowed to continue and magentometer readings were taken at 2-foot intervals to a minimum depth of 6 feet bgs or to the maximum depth of the soil boring

3.2 PLANT TISSUE AND SOIL SAMPLING

The plant tissue sampling was performed in support of the results and conclusions of the Phase II ecological validation study at Sites FTIR-38 Area 2, FTIR-40 Area 1.1, and FTIR-40 Area 2, based on recommendations from the meeting on March 10, 1999 with the DTSC, California Department of Fish and Game (CDFG), USACE, MWH, and Fort Irwin (see Appendix C). The results of the plant tissue sampling would be used to further characterize potential ecological risks to the Mojave ground squirrel, as part of the baseline ERA and Phase II ecological validation study. The other sub-sites were also recommended for plant tissue sampling in the SI Report (Montgomery Watson, 1998); however, it was later determined that plant tissue sampling was not necessary at these sites. These sub-sites were eliminated from plant tissue sampling requirements for the following reasons:

- Site FTIR-38 Area 1 has no vegetation and, therefore, no complete exposure pathway for the Mojave ground squirrel.
- Site FTIR-40 Area 1.2 is an area of metallic debris (designated in the March 10, 1999 meeting as Area 1.2) that had detections of metals within background ranges and, therefore, is eliminated from plant tissue sampling.

The following subsections address target plant species, plant tissue sampling locations, and tissue sampling and analysis.

3.2.1 Targeted Plant Species

The targeted plant species identified as potential food sources for the Mojave Ground Squirrel are:

- Coreopsis (*Coreopsis sp.*)
- Desert thorn (*Lycium sp.*)
- Fiddleneck (*Amsinckia sp.*)
- Joshua tree (*Yucca brevifolia*)
- Russian thistle (*Salsola tragus, S. kail, S. iberica, S. australis*)

These plant species comprise the majority of the diet for the Mojave ground squirrel (Recht, 1977; Zembal and Gall, 1980; and Krzysik, 1994). The Mojave ground squirrel is observed to sequentially feed on these plants on a seasonal basis i.e., desert thorn is preferentially consumed in early spring while Russian thistle is consumed in the summer. The order of preference for the plant species by the Mojave ground squirrel is largely a function of the plant's water content and seasonal availability (Recht, 1977). The Mojave ground squirrel has also been observed to harvest the seeds of the Joshua tree in mid-June through mid-July. However, the Joshua tree is not as abundant as the other four plant species and does not bloom or bear fruit every year (Zembal and Gall, 1980).

3.2.2 Sampling Locations

Plant tissue samples were collected from Site FTIR-38 Area 2, Site FTIR-40 Area 1.1, and Site FTIR-40 Area 2, and analyzed for metals. Due to the limited number of plants at each site, the method of obtaining plant tissue samples varied from the Workplan for Sites FTIR-32A, FTIR-38, FTIR-39, and FTIR-40 (Montgomery Watson, 1999). A grid was not established, and instead, samples were collected from the plants available at each site that were listed as a potential Mojave ground squirrel food source. The sampling locations for Site FTIR-38 Area 2 and Site FTIR-40 Area 1.1 and Area 2, are presented on Figures 3-1 and 3-2, respectively. In addition, surface soil samples were collected from the location of each plant tissue sample; the results of the plant tissue and surface samples were used to support the Phase II ecological validation study (Section 7.0). A qualified onsite biologist with May Consulting Services of Walnut Grove, California, was subcontracted by MWH to provide assistance in identifying specific plant species and parts of these plants for sampling, and collecting samples.

Plant tissue and collocated surface soil samples were also collected from two reference areas to establish the background metal concentrations in plants from areas that are relatively unimpacted by military activities (see Figures 3-1 and 3-2). During a site visit on March 10, 1999, the CDFG identified the two reference areas as Reference Areas RF1 and RF2 for Sites FTIR-38 and FTIR-40, respectively. These reference areas were selected because of their limited use for military activities and the similar physical characteristics (i.e., soil type and elevation) and biological conditions (i.e., habitat type and plant communities) to the sites under investigation.

3.2.3 Plant Tissue Sampling and Analysis

The species from which plant tissue samples were collected varied from those in the Workplan due to the unseasonably dry year and the previous use and disturbance of the areas in question. A report prepared by May Consulting Services on the plant tissue sampling activities is presented in Appendix D. Dried specimens of what appeared to be fiddleneck (*Amsinckia spp.*) were present at all of the study sites; however, because these specimens were dry at the time of the field study, they could not be analyzed. There were no live Russian thistle plants at any of the sites, and the only Joshua tree present was in Reference Area RF1 and it was not bearing fruit at the time of the survey. So these species could not be sampled either (May Consulting Services, 1999).

Anderson's box-thorn (desert-thorn) was the most abundant targeted plant species at Area 1.1 and Area 1.2 of Site FTIR-40 and at the two reference areas. There were adequate specimens to collect desert thorn plant tissue samples from all study sites, with the exception of Site FTIR-38 Area 2 where only one plant was observed. Therefore, tissue samples were collected from similar, non-targeted plant species, including shadscale (*Atriplex confertifolia*), spinescale (*Atriplex spinifera*), and hop-sage (*Grayia spinosa*) from Site FTIR-38 Area 2 and at Reference Area RF1 (May Consulting Services, 1999). This collection of similar, non-targeted plant species is not expected to affect exposure estimates appreciably in the Phase II ecological validation study (Section 7.0), due to the variability inherent in biological sampling. However, this issue does contribute to a degree of uncertainty in the exposure assessment for the Mojave ground squirrel at Site FTIR-38 Area 2.

Approximately 10 to 25 grams (wet weight) of plant tissue were collected from each specimen and placed on ice in pre-cleaned resealable plastic bags. These plant samples were analyzed for metals and moisture content. The moisture content results were used to convert plant wet weight values to dry weight. A list of metals that were analyzed for each site is shown on Table 3-2.

This list includes the metals that were identified as risk drivers during the SI (Montgomery Watson, 1998) as well as several additional metals that were listed as risk drivers in a letter from DTSC (see Appendix C).

3.3 SOIL BORING SAMPLING

As discussed in Section 2.1.4, Site FTIR-40 Area 2 is thought to be a potential septic tank leach field. Therefore, five soil borings were investigated at this site to further evaluate the extent of contamination. As presented in Figure 3-2, two soil borings (40-2-SB-1 and 40-2-40-2) were excavated within the depressions extending from the septic tank and the remaining soil borings were located around the potential leach field area Soil samples were collected at depths of 2.5, 5, and 10 feet bgs and analyzed for SVOCs and metals

Soil borings were advanced using a truck-mounted hollow stem auger. Soil samples were collected by driving a split spoon sampler lined with 6-inch stainless steel sleeves. The soil cuttings that were generated from the drilling were mixed with cement to stabilize the contaminants in the soil and then placed back into the boring. An additional sample (40-2-SB-CUTTINGS) was collected from the soil cuttings and analyzed for soluble threshold leaching concentration (STLC) and toxicity characteristic leaching procedure (TCLP) to characterize the soil for potential future disposal.

3.4 X-RAY FLUORESCENCE SAMPLING

To further characterize the extent of lead contamination at Site FTIR-38 Area 2, soil samples were collected from all eighteen berms at this site and four additional berms located near the airplane runway at the east side of the site These four off-site berms are shown on Figure 3-3. Samples were also collected from the lakebed surrounding the berms. The soil sample locations are presented on Figures 3-3 and 3-4. These soil samples were analyzed using the XRF method in a mobile laboratory XRF is a direct energy XRF tabletop system made by Spectrace; the hardware consists of an XRF unit with a rhodium x-ray tube and a dedicated computer with software. The XRF Technical Procedure is presented in Appendix E.

Based on field observations, the bullets were fired into the southern face of the berms and these locations were the most heavily impacted. Therefore, a single surface soil sample was collected from the center of the southern face of each berm. The surface soil samples were then passed through a #4 sieve and submitted to the mobile laboratory for XRF analysis. If the XRF results indicated that the lead concentration was equal to or greater than the action level of 50 mg/kg, then an additional sample was collected in the same location at 1-foot into the berm, sieved, and analyzed. Again, if the XRF result for the 1-foot sample was greater than the action level, a third sample was collected from this location at 2 feet into the berm. This procedure is repeated until the XRF results were below the action level. On the other hand, if lead was detected below the action level in the initial surface sample, then two samples were collected from the surface of the berm (one sample on each opposing end to determine whether the targets were placed in the middle of the berm). The decision tree for XRF sampling at each of the berms is presented on Figure 3-5.

The area surrounding the berms was also sampled to determine the lead concentrations in the soils on the lakebed. A surface soil sample was collected from the base of each of the berms. The soil samples were sieved and submitted for XRF analysis. If the lead concentrations were greater than the action level of 50 mg/kg, then two additional samples were collected; one in the same location at 1-foot bgs and another from the surface at 40 feet to the southeast of the berm. If the lead concentration in the second surface soil sample was greater than the action level, then the same procedure is repeated; a sample was collected at 1-foot bgs at the same location as the second surface sample and an additional sample was collected at another 40 feet to the southeast of the berm beyond the previous sample location. This strategy of "stepping out" allowed for a more complete determination to be made on the extent of contamination. The decision tree for XRF sampling in the areas surrounding the berms is presented on Figure 3-6.

In addition to the above, surface soil samples were collected at designated locations illustrated on Figures 3-3 and 3-4 to provide adequate coverage of the area comprising Site FTIR-38 Area 2. The field team leader made the final determination on the number of samples that were necessary to delineate the boundary of lead contamination in the soil. Twenty percent of the XRF samples were submitted to Applied Physics and Chemistry Laboratory (APCL), a stationary analytical laboratory, for confirmation and ten percent of the XRF samples were collected as field duplicates and sent to the mobile laboratory for analysis.

Furthermore, five of the soil samples that appeared to have been impacted the most by bullets were also analyzed for bullet count in order to estimate bulk lead at Site FTIR-38 Area 2. A bullet count analysis was conducted by taking a known volume of soil and passing through a #10 sieve. The bullets and bullet fragments were counted and an average bullet count was estimated. Two of the surface soil samples collected were also analyzed for the TCLP and STLCs in order to characterize the soil for potential future disposal.

3.5 LAND SURVEYING

The soil boring, plant tissue sample, and XRF sample locations were surveyed by EDB and Associates from Rancho Cordova, California. The coordinates of each sampling location were referenced to pre-existing permanent land monuments. These land monuments were in turn referenced to the established coordinate system at NTC, Fort Irwin. The location of each point was determined to the nearest 1 foot. The land survey data is included in Appendix F.

3.6 ANALYTICAL PROCEDURES AND QUALITY ASSURANCE/ QUALITY CONTROL EVALUATION

Analytical procedures were outlined in the Chemical Data Acquisition Plan (CDAP) presented in the Parsons ES Workplan, Appendix D (Parsons ES, 1995). The laboratory subcontracted for the chemical analysis of soil samples was APCL located in Chino, California. The XRF analysis performed at Site FTIR-38 Area 2 was conducted by Onsite Environmental Laboratories (Onsite) located in Emeryville, California. Both laboratories are validated by the USACE through the Center of Expertise (CX) and are certified by the California Environmental Protection Agency (Cal-EPA) Department of Health Services (DHS) through the Environmental Laboratory Accreditation Program (ELAP) to perform hazardous waste analyses.

Quality assurance (QA) split samples were collected at each of the locations where field duplicate samples were collected. The QA split samples were submitted to Agriculture and Priority Pollutant Laboratories (APPL) located in Fresno, California, for chemical analysis. The results of the QA split samples were submitted directly by APPL to the USACE project manager (PM) and are not presented as part of this report.

3.6.1 Analytical Methods and Sampling Program

Between May 10 and 22, 1999, a total of 50 plant tissue samples (including five field duplicates), 50 co-located soil samples (including five field duplicates), 14 subsurface soil samples (including two field duplicates), 312 XRF samples (including 37 field duplicates), and 67 XRF confirmation samples were collected at Sites FTIR-38 Area 2, FTIR 40 Area 1 and Area 2, plus two reference sites. Additionally, USACE collected two soil samples from Site FTIR-38 Area 1 on July 19, 1998. Table 3-1 provides the field identification, laboratory identification, and the analyses requested for each sample. Analytical results of these samples are provided in a tabular format in Appendix G. Copies of all sample chain-of-custody documents are included in Appendix H. The analyses performed included the following:

- Metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, vanadium, zinc) by USEPA Method 6010B
- Mercury by USEPA Method 7471A
- Soluble metals by STLC and TCLP
- SVOCs by USEPA Method 8270C
- Nitrate as nitrogen by Standard Method 4500
- Nitrite as nitrogen by USEPA Method 354.1
- Moisture by American Society of Test Methods (ASTM) D 2216

All samples were analyzed in accordance with the protocols established in the CDAP.

At Site FTIR-38 Area 2, samples were screened for lead in the field by energy dispersive x-ray fluorescence (EDXRF). Twenty percent of the screening samples were split and sent to APCL for confirmation analyses. The samples at APCL were analyzed for lead using inductively coupled plasma spectroscopy (ICP). The overall correlation between EDXRF results and ICP results is 0.8383. However, results for four data points (38-2-SS-2-1, 38-2-SS-191, 38-2-SS-27-1, and 38-2-SS-70-1) were significantly skewed. When these data points are removed from the calculation, the correlation between EDXRF and ICP results is 0.9440. A comparison of EDXRF values and confirmation results is provided in Table E-1 and Figure E-1 in Appendix E. This indicates that the EDXRF results are reliable.

3.6.2 Data Validation

MWH performed data validation of all sample results, using both USEPA Level III (definitive data with quality control [QC] summaries) and IV (raw data packages) guidelines. Ten percent of the data was validated using the Level IV guidelines, and the remaining 90 percent was validated using the Level III guidelines. Data was validated using the following documents, as applicable to each method:

- USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, February (USEPA, 1999a)
- USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, February (USEPA, 1994a)
- USEPA SW 846, Third Edition, Test Methods for Evaluation of Solid Waste, update 1, July 1992; update IIA, August 1993; update II, September 1994; update IIB, January 1995; update III, December 1996 (USEPA, 1996)
- CDAP (Parsons ES, 1995)

The data validation reports, which include complete summaries of data validation qualifiers, are included in Appendix I and are organized by analytical parameter. An overview of findings is presented below. The definitions of these qualifier flags are as follows:

U	Indicates the compound or analyte was analyzed for but not detected at or above the stated limit
J	Indicates an estimated value
R	Quality control indicates the data is not usable.
N	Indicates presumptive evidence of the constituent presence
UJ	Indicates the compound or analyte was analyzed for but not detected. The sample detection limit is an estimated value

3.6.3 Quality Control Results

This section provides a summary of the field and laboratory QC sample results which were used to meet the project data quality objectives (DQOs) for the investigation. The following subsections summarize the validation findings in terms of the precision, accuracy, representativeness, completeness, and comparability (PARCC) criteria as defined in Section 7.6.5 of the CDAP (Parsons ES, 1995).

3.6.3.1 Precision and Accuracy. Precision and accuracy were evaluated based on the results from QC samples collected by the field team and QC samples that originated in the laboratory. The calculated relative percent difference (RPD) for matrix spike/matrix spike duplicates (MS/MSDs) and field duplicate pairs provided information on the precision of sampling and analytical procedures. Evaluation of the percent recovery of internal standards, surrogate compounds, and spiked analytes in MS/MSDs and laboratory control samples (LCSs) provided information on accuracy. In addition, the initial and continuing calibration results provided information on analytical accuracy

Significant validation findings are summarized below. Detailed findings are presented in Appendix I.

Initial Calibrations. All initial calibrations were within the established control limits for all events with the following exceptions:

- The percent relative standard deviation (%RSD) for 2-aminonaphthalene (30.67 percent) from the calibration conducted on May 13, 1999 was outside of the control limits of ± 30 percent. Associated sampled included 40-2-SB-1-10.0, 40-2-SB-1-2.5, 40-2-SB-1-5.0, 40-2-SB-1-5.0 (field duplicate), 40-2-SB-2-10.0, 40-2-SB-2-10.0 (field duplicate), 40-2-SB-2-5.0, 40-2-SB-3-10.0, 40-2-SB-3-2.5, 40-2-SB-3-5.0, 40-2-SB-4-10.0, 40-2-SB-4-2.5, 40-2-SB-4-5.0, 40-2-SB-5-10.0, 40-2-SB-5-2.5, and 40-2-SB-5-5.0. This exceedance was considered negligible (30.67% vs. 30%), thus the associated results were not flagged

Continuing Calibrations. All continuing calibration verifications were within the established control limits for all events with the following exceptions:

- The percent difference (%D) for benzyl alcohol (33.6 percent), benzoic acid (-25.5 percent), and benzidine (33.6 percent) exceeded the control limits of ± 25 percent. Associated samples included 40-2-SB-1-10.0, 40-2-SB-1-2.5, 40-2-SB-1-5.0, 40-2-SB-1-5.0 (field duplicate), 40-2-SB-2-10.0, 40-2-SB-2-10.0 (field duplicate), 40-2-SB-2-5.0, 40-2-SB-3-10.0, 40-2-SB-3-2.5, 40-2-SB-3-5.0, and 40-2-SB-4-2.5. All results for these compounds in these samples were non-detect, and therefore, the "UJ" flag has been applied.
- The %D for benzoic acid (-46.8 percent), and 4,6-Dinitro-2-methylphenol (-26 percent) exceeded the control limits of ± 25 percent. Associated samples included 40-2-SB-4-10.0, 40-2-SB-4-5.0, 40-2-SB-5-10.0, 40-2-SB-5-2.5, and 40-2-SB-5-5.0. All results for these compounds in these samples were non-detect, and therefore, the "UJ" flag has been applied.

Internal Standards. All internal standard recoveries were within the established control limits.

Laboratory Control Samples. LCSs were analyzed for all pertinent methods for Sites FTIR-38 and FTIR-40. All LCS recoveries were within the established control limits

Matrix Spike/Matrix Spike Duplicates. Out-of-control events were identified for the following samples and compounds. For low recoveries or bias, detected results in the spiked sample were qualified as estimated and flagged "J", and non-detects were flagged "UJ". For high recoveries or bias, detected results were qualified as estimated. For recoveries below 30 percent, detected results were qualified as estimated and flagged "J", and non-detects were qualified as not usable and flagged "R". Out-of-control events involving MS/MSD pairs included:

- The matrix spike and matrix spike duplicate recoveries for zinc (0 and 67 percent) and the RPD (200 percent) in sample 40-2-SS-8 were outside of the project control limits.

Surrogate Recoveries. All surrogate recoveries were within the established control limits.

Field Duplicates. A summary of field duplicate results is provided in Table J-1 of Appendix J of this report. Additionally, field duplicate results are summarized in each of the data validation reports by analytical parameter (summaries are provided in Appendix I). The criteria specified in the CDAP are included in the validation reports. While several RPDs were outside of the control limits specified in the CDAP, there is no qualification criteria outlined the National Functional Guidelines for Organic Data Review (USEPA, 1994a) for field duplicate RPD evaluation. Therefore, qualifications were not applied to these results. The following samples and compounds/analytes were outside of the established control limits:

- The RPDs for aluminum (84.4 percent) and barium (91.2 percent) in sample 38-2-PT-3A exceeded the control limit of 70 percent.
- The RPD for manganese (116.8 percent) in sample 40-1-PT-3 exceeded the control limit of 70 percent.
- The RPD for selenium (80 percent) in sample 40-1-SS-3 exceeded the control limit of 70 percent.
- The RPD for bis(2-Ethylhexyl) phthalate (104 percent) in sample 40-2-SB-1-5.0 exceeded the control limit of 70 percent.
- The RPD for lead (83.1 percent) in sample RF2-PT-4 exceeded the control limit of 70 percent.

Laboratory Duplicates. All RPDs for laboratory duplicate met the established control limits.

ICP Serial Dilution. All ICP serial dilutions were within the established control limits with the following exceptions. The "J" flag has been applied to indicate sample results are an estimate.

- The ICP serial dilution %D of lead (41.8 percent) in sample 38-2-SS-CNF-36 exceeded the control limits of $\pm$ 10 percent. Associated samples included 38-2-SS-CNF-20, 38-2-SS-CNF-22, 38-2-SS-CNF-23, 38-2-SS-CNF-25, 38-2-SS-

CNF-28, 38-2-SS-CNF-29, 38-2-SS-CNF-30, 38-2-SS-CNF-33, 38-2-SS-CNF-36, and 38-2-SS-CNF-11-1'.

- The ICP serial dilution %D of lead (13 percent) in sample 38-2-SS-CNF-64 exceeded the control limits of ± 10 percent. Associated samples included 38-2-SS-CNF101, 38-2-SS-CNF28-1, 38-2-SS-CNF37-1, 38-2-SS-CNF37-2, 38-2-SS-CNF42-1, 38-2-SS-CNF-49-1, 38-2-SS-CNF49-2, 38-2-SS-CNF50-2, 38-2-SS-CNF53-2, 38-2-SS-CNF64, 38-2-SS-CNF66, 38-2-SS-CNF68-1, 38-2-SS-CNF74, 38-2-SS-CNF82, 38-2-SS-CNF84, 38-2-SS-CNF91, and 38-2-SS-CNF92.

3.6.3.2 Representativeness. Representativeness was assessed through the evaluation of blank samples (method, initial calibration, continuing calibration, preparation, and trip blanks) and by the interference check samples for metals. Additionally, sample collections and handling methods and the cooler receipt forms were reviewed. All sample bottles were received in good condition and the chain-of-custody documents agreed with the sample labels. A summary of the validation findings is presented below. Detailed findings are presented in Appendix I.

- The method blanks from May 19, 1999 (99M1840 and 99M1842) contained selenium (0.12 mg/kg and 0.13 mg/kg, respectively). Associated samples included 40-1-PT-1, 40-1-PT-3, 40-1-PT-3, 40-1-PT-3 (field duplicate), 40-1-PT-4, 40-1-PT-5, 40-PT-1-6, 40-PT-1-7, 40-1-PT-8, 40-1-PT-9, and 40-1-PT-10.

3.6.3.3 Completeness. Completeness of data was evaluated by assuring that all the analytical requests were met, samples were received in the proper condition, and all analyses were performed within the appropriate holding times. Overall completeness for Sites FTIR-38 and FTIR-40 (100 percent) exceeded the project goal of 90 percent for all QC parameters.

3.6.3.4 Comparability. To ensure the comparability of the data, field procedures were standardized by adhering to the standard operating procedures (SOPs), and laboratory procedures followed USEPA analytical methods which utilize standard units of measurement. All project-required reporting limits were met with the following exceptions.

- **SVOCs:** The following SVOC compounds had reporting limits greater than those specified in the CDAP: 2-nitroaniline (280 micrograms per kilogram [μg/kg] instead of 170 μg/kg), 3,3-dichlorobenzidine (240 μg/kg instead of 170 μg/kg), 3-

nitroaniline (2600 µg/kg instead of 170 µg/kg), 4,6-dinitro-2-methylphenol (290 µg/kg instead of 170 µg/kg), 4-chloroaniline (330 µg/kg instead of 170 µg/kg), 4-nitroaniline (260 µg/kg instead of 170 µg/kg), chrysene (520 µg/kg instead of 170 µg/kg), N-nitrosodimethylamine (520 µg/kg instead of 170 µg/kg), and pentachlorophenol (490 µg/kg instead of 170 µg/kg); the remaining target compounds were also reported slightly above the CDAP reporting limit requirement (refer to Appendix I for complete list).

- **Metals:** The following metals had reporting limits greater than those specified in the CDAP: calcium (60.6 mg/kg instead of 15 mg/kg), iron (12.1 mg/kg instead of 8 mg/kg), magnesium (60.6 mg/kg instead of 20 mg/kg), potassium (606 mg/kg instead of 300 mg/kg), and sodium (160 mg/kg instead of 40 mg/kg).
- **Soluble Metals:** The following soluble metals (STLC and TCLP) had reporting limits greater than those specified in the CDAP: arsenic (25 µg/L instead of 10 µg/L), barium (50 µg/L instead of 10 µg/L), beryllium (5 µg/L instead of 3 µg/L), cadmium (10 µg/L instead of 8 µg/L), calcium (800 µg/L instead of 150 µg/L), copper (50 µg/L instead of 20 µg/L), iron (100 µg/L instead of 80 µg/L), lead (25 µg/L instead of 10 µg/L), magnesium (250 µg/L instead of 200 µg/L), manganese (25 µg/L instead of 5 µg/L), mercury (0.5 µg/L instead of 0.2 µg/L), selenium (50 µg/L instead of 10 µg/L), sodium (5000 µg/L instead of 400 µg/L), thallium (50 µg/L instead of 20 µg/L), and vanadium (50 µg/L instead of 15 µg/L).
- **Wet Chemistry:** Nitrate as nitrogen had a reporting limit greater than that specified in the CDAP (5.2 mg/kg instead of 0.10 mg/kg).

Necessary sample dilutions, due to the presence of elevated target compound concentrations, did not affect data usability and comparability. Results for some analytes are reported below the project-required reporting limits (RLs) but above the method detection limit (MDL). The "J" flag has been applied to results reported between the MDL and RL. Comparability of the data presented in this report is acceptable with the exceptions noted above.

3.6.4 Quality Control Summary

The field and analytical procedures for this investigation were followed as described in the Workplan and CDAP with the exceptions noted above. All qualified data are summarized in Appendix I. All data associated with this investigation are usable as qualified.

4.0 NATURE AND EXTENT OF SITE IMPACTS

This section discusses the nature and extent of impacts at Sites FTIR-38 Area 1, FTIR-38 Area 2, FTIR-40 Area 1.1, and FTIR-40 Area 2 based on previous investigations and the results of the RI activities. RI activities included plant tissue sampling, surface and subsurface soil sampling and XRF sampling. Well abandonment activities at Goldstone Well A are also described in this section.

The following sections provide a summary of the analytical results on a site-by-site basis. The analytical results were compared to site BUTLs established for inorganic material in soil (Table 4-1). The PRGs for SVOCs that were detected are also provided in Table 4-1.

4.1 SITE FTIR-38 AREA 1

4.1.1 Soil Sampling Results

In July 1998, the USACE collected subsurface soil samples from Site FTIR-38 Area 1 and analyzed them for metals to determine the vertical extent of metal contamination at this site. The samples were collected at 2 and 5 feet bgs within the circle of drums at sample location 38-1-SS-2 (Figure 4-1). The analytical results for the two soil samples (38-1-SS-2-2 and 38-1-SS-2-5) are presented in Table 4-2 and summarized in Figure 4-1.

The following metals in the 2-foot-bgs sample were detected at levels greater than twice the BUTLs: copper (49.9 mg/kg), lead (105 mg/kg), manganese (801 mg/kg) sodium (6,590 mg/kg), and zinc (149 mg/kg). Several other metals were detected at concentrations slightly greater than background: aluminum (30,000 mg/kg), barium (198 mg/kg), calcium (26,500 mg/kg), iron (39,200 mg/kg), magnesium (14,400 mg/kg), and potassium (10,300 mg/kg). The concentrations of all metals, with the exception of arsenic, calcium, magnesium, vanadium, and zinc, appear to decrease with depth. In the 5-foot-bgs sample, calcium (110,000 mg/kg), lead (23.2 mg/kg), magnesium (23,500 mg/kg), and zinc (215 mg/kg) were detected at concentrations greater than twice BUTLs. Arsenic, iron, and sodium were also detected above BUTLs in this sample. Concentrations of other metals analyzed in the 5-foot-bgs sample were below BUTLs.

4.2 SITE FTIR-38 AREA 2

4.2.1 Plant Tissue and Soil Sampling Results

Eleven soil and plant tissue samples, including two field duplicate samples, were collected from Site FTIR-38 Area 2. Plant tissue samples were co-located with soil samples. Samples were collected from the area surrounding the most visually impacted northeast and southwest berms, shown in Figure 3-1. Desert thorn (*Lycium andersonii*) was only one of the plant species listed in the Workplan (Montgomery Watson, 1998) that was identified at this site. The most abundant species found was saltbush which is not a listed food source for the Mojave Ground Squirrel (May Consulting Services, 1999). However, during a discussion with the biologist stationed at Fort Irwin, it was discovered that the Mojave Ground Squirrel may eat other plant species if their preferred food source is unavailable. Therefore, ten samples of saltbush (*Larrea tridentata*) and one sample of desert thorn were collected and analyzed for metals.

Eleven plant tissue and co-located surface soil samples, including two field duplicate samples, were also collected from at Reference Area RF1 that is located to the east of Site FTIR-38 Area 2 (Figure 3-1). The plant tissue samples were collected from the same plant species as those collected at Site FTIR-38 Area 2 The plant tissue and surface soil analytical results for Site FTIR-38 Area 2 and Reference Area RF1 are presented in Tables 4-3 and 4-4, respectively, and summarized in Figure 4-2.

All surface soil samples but one that were collected from Site FTIR-38 Area 2 contained lead concentrations at least twice the BUTL; these concentrations range between 16.7 mg/kg and 183 mg/kg. Aluminum, barium, copper, and zinc were also detected at concentrations that exceed their respective BUTLs in the vicinity of berms B4 and B7 in the southwest area. Copper and zinc were detected above the BUTLs in the vicinity of berms B2, B3, and B8 in the northeast area. Soil sample analyses from Reference Area RF1, reported lead concentrations slightly exceeded the BUTL in these samples; however, these concentrations are considered representative of its BUTL (Table 4-4). All other metals were below BUTLs in the surface soil samples.

Comparison of the surface soil sampling analytical results between Site FTIR-38 Area 2 and Reference Area RF1 confirms that the surface of the soil berms contain higher than BUTLs of lead, aluminum, zinc, copper and barium. The highest concentrations were detected in the vicinity of berms B4 and B7 in the southwest area and berms B2, B3, and B8 in the northeast area.

Concentrations of metals that were analyzed for in plant tissue samples collected from Site FTIR-38 Area 2 were similar to those from Reference Area RF1, as shown in Tables 4-3 and 4-4. This suggests that plants at this site are not "bioaccumulating" the metals, including aluminum, antinomy, arsenic, barium, cobalt, copper, lead, and zinc. A more detailed discussion and analysis of the plant tissue sampling results is presented in Section 7.0.

4.2.2 X-Ray Fluorescence Soil Sampling Results

XRF samples were collected from all eighteen berms and from the areas surrounding the berms at Site FTIR-38 Area 2 to further characterize the extent of lead contamination, as described in Section 3.4. The XRF Technical Procedure is presented in Appendix E. The results from the XRF analysis for the northeast and southwest berms are summarized in Tables 4-5 and 4-6, respectively. These results have been utilized to create lead concentration maps for surface soil (the first 1 foot bgs) which are presented in Figures 4-3 and 4-4 for the northeast and southwest berms, respectively. To fully characterize the extent of lead impacts to soil, the XRF and all previous soil data was compiled onto Figures 4-3 and 4-4. Figures 4-5 and 4-6 present all lead analyses in subsurface soil at the northeast and southwest berms, respectively. Additionally, all XRF sampling locations and results are presented on a figure in Appendix K.

Figures 4-3 and 4-4 show that the surface soils (0 to 1 feet bgs) at and surrounding northeast berms B1, B2, B3, B8, and B9 and southwest berms B4, B5, B6, and B7 contained lead at concentrations ranging between 400 mg/kg and 4000 mg/kg. Additionally, the southern face of northeast berm B3 contained a lead concentration of 5,200 mg/kg which was detected at 1 foot bgs. The berms in the back rows (B11, B12, B13, B14, B15, and B16) contained lower levels of lead (between 10 mg/kg and 34 mg/kg). These results suggest that lead concentrations in surface soils are higher in the southern-facing side of all berms which are located closest to the observation tower and the runway.

Figures 4-5 and 4-6 show that subsurface soils from 2 to 4 feet bgs at the northeast berms and from 2 to 5 feet bgs at the southwest berms contain lower lead concentrations. Although lead concentrations are lower at these depths, these concentrations remain higher than the BUTL of 7.33 mg/kg. The vertical profiles of lead concentration with soil depth for the most lead-impacted berms (B2, B3, B8, B4, and B7) are shown in Figure 4-7. This figure clearly illustrates that elevated lead concentrations (exceeding 500 mg/kg) are restricted to the first two feet of the surface soil and that lead has a very low mobility in soil.

Four XRF samples were also collected from the off-site berms and lead was detected at concentrations ranging between 10 mg/kg and 17 mg/kg in these samples (Table 4-7).

In summary, for all the surface and 1 foot bgs soil samples collected, the highest concentrations of lead were detected in southwest berms B7 and B4. These two berms are located closest to the observation tower. For all berms, concentrations of lead were noted to decrease with increasing distance from the center of the berms and with increasing depth. Higher lead concentrations appear to be concentrated on the south-side of the berms which face the tower and runway.

4.3 SITE FTIR-40 AREA 1.1

4.3.1 Plant Tissue and Soil Sampling Results

Eleven plant tissue and co-located surface soil samples, including two field duplicates, were collected from Site FTIR-40 Area 1.1 and analyzed for metals. The sample locations are presented in Figure 3-2. Vegetation at Site FTIR-40 Area 1.1 is dominated by creosote bush (*Larrea tridentata*), Anderson's box-thorn (*lycium andersonii*), ephedra (*Ephedra spp.*), and white bursage (*Ambrosia dumosa*). Herbaceous plants are largely absent except for scattered annual buckwheats (*Eriogonum spp.*). Of these plant species, only Anderson's box-thorn was identified as a potential food source for the Mojave ground squirrel. Therefore, plant tissue samples were only collected from Anderson's box-thorn at Site FTIR-40 Area 1.1.

The vegetation at Reference Area RF2 is similar to Site FTIR-40 Area 1.1 and *Lycium andersonii* was the only species from which ten primary and one duplicate plant tissue samples were collected and analyzed. Ten primary and one duplicate surface soil samples were also collected and analyzed (Figure 3-2). The analytical results for Site FTIR-40 Area 1.1 and Reference Area RF2 are presented in Tables 4-8 and 4-9, respectively, and summarized in Figure 4-8.

Lead and zinc concentrations were higher than BUTLs in several surface soil samples collected from Site FTIR-40 Area 1.1. Concentrations were at least six times higher than the BUTLs in the 40-1-SS-2 and 40-1-SS-8 samples; lead concentrations were 1,060 mg/kg and 306 mg/kg, respectively; and zinc concentrations were 116 mg/kg and 124 mg/kg, respectively. Soil samples 40-1-SS-2 and 40-1-SS-8 also contained elevated levels of copper (45.9 mg/kg and 127 mg/kg, respectively) and barium (205 mg/kg and 241 mg/kg, respectively). Levels of manganese were detected to be greater than its BUTL in all but one soil sample. The remaining metals were not detected above BUTLs in any of the surface soil samples. As for the surface soil samples collected from Reference Area RF2, barium, lead, manganese and zinc concentration values were slightly higher than the BUTLs in at least five of the samples.

Comparing the soil sample results between Site FTIR-40 Area 1.1 and Reference Area RF2 suggests that the surface soils in the area of concentrated metallic debris at the former site have higher than BUTLs of lead, zinc, copper and barium. Manganese concentrations in Site FTIR-40 Area 1.1, although higher than BUTLs in most samples, are similar to those detected in Reference Area RF2.

For the plant tissue samples, concentrations of cadmium and zinc in sample 40-1-PT-2 from Site FTIR-40 Area 1.1 were higher than those in the plant tissue samples from RF2 (Table 4-8). Concentrations of other metals in the plant tissue samples collected from Site FTIR-40 Area 1.1 were similar to those from Reference Area RF2. A more detailed discussion and analysis of the plant tissue sampling results are presented in Section 7.0.

4.4 SITE FTIR-40 AREA 2

4.4.1 Plant Tissue and Soil Sampling Results

Ten primary surface soil and co-located plant tissue samples were collected from Site FTIR-40 Area 2. Two duplicate surface soil and plant tissue samples were also collected. All the 22 samples were analyzed for arsenic, cadmium, lead and zinc. The analytical results are presented in Table 4-10, and summarized in Figure 4-9. Creosote bush *(Larrea tridentata)* is the dominant shrub at this site with white bursage (*Ambrosia dumosa*) and Anderson's box-thorn (*Lycium andersonii*) being the sub-dominant species. Cooper's box-thorn (*Lycium cooperi*) is also present at the site in limited numbers. Herbaceous plants are largely absent except for scattered desert trumpet (*Eriogonum inflatum*) and dried fiddleneck plants (*Amsinckia spp.*). As explained in Section 3.2.3, *Amsinckia spp.* was too dry for analysis and all the plant tissue samples were collected from *Lycium andersonii* and *Lycium cooperi*.

Concentrations of lead and zinc that exceeded BUTLs were detected in most surface soil samples, with particularly high values in samples 40-2-SS-3 (259 mg/kg and 213 mg/kg, respectively) and 40-2-SS-4 (30.1 mg/kg and 74.5 mg/kg, respectively). Concentrations of arsenic and cadmium were detected at slightly above BUTLs in six and one of the eleven surface soil samples, respectively.

Based on the above findings and the results obtained from Reference Area RF2 described at the end of section 4.3.1, the surface soils at Site FTIR-40 Area 2 contain elevated levels of lead and zinc. The concentrations of these two metals appear to decrease with distance from the center of Site FTIR-40 Area 2.

Concentrations of zinc in several of the plant tissue samples collected from Site FTIR-40 Area 2 were higher than the concentrations in plant tissue samples collected from Reference Area RF2. Concentrations of other metals (arsenic, cadmium, and lead) detected in the plant tissue samples at Site FTIR-40 Area 2 were similar to those from Reference Area RF2. A more detailed discussion and analysis of the plant tissue sampling results is presented in Section 7.0.

4.4.2 Septic Tank/Leachfield Soil Sampling Results

Five soil borings (40-2-SB-01 through 40-2-SB-05) were excavated to investigate the potential septic tank leachfield at Site FTIR-40 Area 2, as described in Section 3.3. Soil samples were collected from the soil borings at depths of 2.5, 5, and 10 feet bgs and analyzed for SVOCs and metals. The soil sample analytical results are presented in Table 4-11, and summarized in Figure 4-9.

Concentrations of arsenic and lead concentrations slightly above BUTLs were detected at depths of 2.5 and 5 feet bgs in at least one sample in each boring. High levels of nitrate were detected at all depths in soil borings 40-2-SB-1 and 40-2-SB-2; these two borings are located closest to the septic tank sump. Calcium concentrations exceed its BUTL at 10 feet bgs in all the five soil borings and were noted to increase with increasing depth. Manganese and barium were detected in the 2.5 feet bgs sample in borings 40-2-SB-1 and 40-2-SB-5 at concentrations exceeding their respective BUTLs. The remaining metals were not detected above the BUTLs in any of the samples. Bis(2-ethylhexyl)phthalate and di-n-octylphthalate were found in several soil samples and concentrations of these compounds generally decreased with depth. The remaining SVOCs were not detected in any of the samples.

The results show that concentrations of nitrate and SVOCs are the highest in the area adjacent to the septic tank sump at Site FTIR-40 Area 2. Concentrations of metals appear to be evenly distributed in the area where the five soil borings were drilled.

4.4.3 Goldstone Well A Abandonment

Goldstone Well A, a former water supply well, is located in the central portion of Site FTIR-40 Area 2, as shown in Figure 1.3 The well was embedded in one of the building foundation concrete slabs. Although no construction or drilling logs were available for this well, the depth of the well was assumed to be approximately 150 feet. The well was likely last used when the area was abandoned in the early 1950's. Previous investigations had indicated that there may have been an obstruction in the well Therefore, a purchase order was issued in September 1998 to video log Goldstone Well A, remove the potential obstruction, and abandon the well by pressure grouting.

MWH contracted with Pro-Pipe of Anaheim, California, to perform the video log of Goldstone Well A on December 11, 1998. The well was found uncovered with an 8-inch steel casing at the surface. During the video logging activity, it was observed that the well had no casing at depths below 24 feet bgs. The steel casing had been completely corroded and the borehole was lined only annular seal material which appeared to be concrete. There were large areas of caving in the sidewalls of the well at depths of 85, 99, 120, and 138 feet bgs. Large crevasses were also evident in the well. However, no obstructions were observed throughout the depth of the borehole The bottom of the borehole was recorded at 176 feet bgs and appeared to be filled in with native material. Water was not encountered at this depth.

West Hazmat Drilling of Anaheim, California, was contracted by MWH to abandon the Goldstone Well A on December 15 and 16, 1998. The well abandonment was conducted according to California Well Standards and consisted of pressure grouting the entire depth of the borehole to the ground surface with neat cement grout mix.

5.0 CONTAMINANT FATE AND TRANSPORT

This section evaluates the effects of site-specific conditions to qualitatively discuss the probable fate of each of the constituents detected in the soils at Sites FTIR-38 and FTIR-40.

Metals. Metals were detected in soil samples at concentrations above background levels at all the sites. The fate of metals in soil is largely controlled by sorption reactions to soil mineral surfaces and humic substances. Sorption of metal ions in the soil is influenced by several factors, including pH, ionic strength, metal concentration, clay content, organic matter content, and soil mineralogy. Soil particle size distribution determines surface area and the quantity of metal binding sites in the soil. Clays and other minerals, including iron oxyhydroxides such as goethite, have higher affinities for binding certain metals than other mineral surfaces. Organic content of soils present at Fort Irwin is extremely low; therefore, retardation of anthropogenic metals by organic matter will be very small.

Total lead is the indicator metal identified in soils in the RI. At Fort Irwin, desert soils tend to be alkaline (pH ranging from 7.5 to 8.5) and calcareous (mineralogy dominated by carbonates). In this environment, any dissolved lead tends to quickly and almost completely form lead precipitates or relatively insoluble hydroxide and carbonate minerals. Lead in these mineral phases is sparingly soluble and is unlikely to migrate downward in the soil profile. Given the relatively low solubility of lead hydroxide and lead carbonate (USEPA, 1992a, Santillan-Medrano and Jurinak, 1975, Dragun, 1988, Harter, 1983, Martel and Smith, 1982) solid to liquid distribution coefficients (K_d) are observed in the range of 3,000 to 35,000 liters per gram (L/g) for California soils (Gao, *et al*, 1995). All available literature indicates that lead partitions strongly to the solid rather than the liquid phase, and given the low rainfall and high evaporation conditions present in the desert, site data suggests that downward migration of lead in soils is limited to the upper 3 feet of soil, as observed in Figure 4-5.

Semi-Volatile Organic Compounds. Low levels of SVOCs, including bis(2-ethylhexyl)phthalate and di-n-octylphthalate, were detected in subsurface soil samples collected from Site FTIR-40 Area 2 While phthalates are commonly found as sampling or laboratory artifacts, they may also be present in soils due to leaching/diffusion from disposed plastics. SVOCs have very low Henry's Law constant values, which limits volatilization; thus sorption and biotransformation are the primary processes controlling these SVOCs in soil/water environments. SVOCs are also highly sorbed to soils. Biodegradation of SVOCs is expected to be slow due to the limited available moisture. The half-lives for transformation of phthalates are expected to be on the order of years. This suggests that phthalates are relatively insoluble, undegradable, and will remain in soil, slowly degrading over time.

Total Recoverable Petroleum Hydrocarbons. TRPH was detected in soil samples collected from Sites FTIR-38 and FTIR-40 during the SI activities in 1998. However, VOCs that are typically associated with petroleum hydrocarbons were not detected at these sites The petroleum hydrocarbons detected in the soils are most likely the longer-chain, less-soluble compounds. These compounds tend to sorb to the soil with only the more soluble constituents dissolving into the soil water. In addition, USEPA Method 418.1, which is used to analyze TRPH, does not distinguish between TRPH and other naturally occurring oils (i e tree sap) or other constituents that can be extracted from total organic carbon; therefore, sample results obtained from this method are often considered to be false positives or elevated high.

As discussed in Section 2.2, groundwater is either absent or found at extreme depths at Sites FTIR-38 and FTIR-40. Therefore, the probability of constituents detected in site soils migrating to groundwater is unlikely. The primary mechanism of transport for compounds that are highly sorbed to soils is surface water runoff, which is limited in this extremely arid environment.

6.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

The baseline HHRA conducted for Sites FTIR-38 and FTIR-40 are presented in this section These assessments were conducted in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Response process, as amended by the Superfund Amendment and Reauthorization Act (SARA), integrated with Installation Restoration Program (IRP) requirements. The goal of the Remedial Response Process is to coordinate and conduct remedial actions as necessary to protect human health and the environment from releases of hazardous substances. The HHRA is intended to provide an analysis of the existing and potential risks that may be posed to human health by contaminants present in site media. The results of the HHRA provide the basis for determining the levels of chemicals that can remain on site and still be protective of human health. This HHRA, in conjunction with the results of the Phase II Ecological Validation Study (Section 7.0), will support the evaluation of a no-action alternative and potential remedial alternatives for each identified source area.

6.1 INTRODUCTION

The baseline HHRA presented in this report was conducted according to the risk assessment methodologies described in the approved *Project Workplan for the SI and RI of 31 Sites at the NTC Fort Irwin, California* (Parsons ES, 1995), hereafter referred to as the Workplan. A screening HHRA was previously conducted for Sites FTIR-38 and FTIR-40 (Montgomery Watson, 1998). Screening cancer risk or non-cancer hazard estimates for Site FTIR-38 Areas 1 and 2 soils exceeded screening criteria for unrestricted (i.e., future residential) land use and future industrial workers. Screening cancer risk and non-cancer hazard estimates for Site FTIR-40 Areas 1.1 and 2 soils also exceeded screening risk criteria for unrestricted land use and future industrial workers. Excess screening risk estimates were primarily associated with the presence of metals in surface and/or subsurface soils.

The screening HHRA for Sites FTIR-38 and FTIR-40 was conducted based upon assumptions regarding unrestricted (i.e., residential) future land use and maximum exposure point concentrations, consistent with DTSC's *Recommended Outline for Using Environmental Protection Agency Region IX Preliminary Remediation Goals in Screening Risk Assessments at Military Facilities* (Cal-EPA, 1994b). However, the baseline HHRA presented in this RI report evaluates risks based upon more realistic assumptions relative to land uses and exposures. As such, the baseline HHRA provides a more realistic evaluation of potential human health impacts. The results of this baseline HHRA are evaluated based upon USEPA's risk management range of 1.0×10^{-6} to 1.0×10^{-4}, and noncancer hazard index (HI) of 1.0 (USEPA, 1991a). Sites for which the cumulative cancer risk and noncancer HI are less than these criteria are generally considered for no further action in regard to human health concerns (USEPA, 1991a). Sites for which the cumulative cancer risk or noncancer HI are greater than these criteria will be evaluated further in the FS.

6.1.1 Purpose and Objectives

The purpose of this baseline HHRA is to provide a qualitative and quantitative evaluation of the potential human health risks associated with exposures of human receptors to chemicals identified in soils at Sites FTIR-38 Areas 1 and 2 and FTIR-40 Areas 1 and 2. Consistent with the approved Workplan (Parsons ES, 1995), baseline human health risks were evaluated for future industrial exposures. In addition, baseline human health risks were evaluated for hypothetical future residents to address potential unrestricted future land use. Exposures and risks for 'current military workers' involved in field training exercises were not evaluated for Sites FTIR-38 and FTIR-40 because these sites are not included within the NTC Fort Irwin range area (please refer to Sections 6.3.1 and 6.3.2). Surface and subsurface soils were evaluated for each of the source areas, except Site FTIR-38 Area 2. For Site FTIR-38 Area 2, only surface soils were evaluated consistent with the surficial nature of the contamination at this site (please refer to Section 4.2). Potential migration of soil contaminants to groundwater, and the possible human health impacts associated with groundwater contamination, were not evaluated in this baseline HHRA. As described in Section 2.2, no aquifers are expected to underlie Sites FTIR-38 and FTIR-40. Therefore, groundwater pathways were not evaluated in this RI/FS report.

The specific objectives of this baseline HHRA were to:

- Identify chemicals of potential concern (COPCs) for each source area and medium.
- Identify potentially exposed receptors based on the expected land use.
- Evaluate completed exposure pathways for each receptor.
- Estimate exposure point concentrations for each COPC.
- Calculate cumulative baseline cancer risks and noncancer HIs for each receptor.

The baseline HHRA for Sites FTIR-38 and FTIR-40 was conducted in accordance with the following guidance documents and reference sources prepared by the USEPA, Cal-EPA, and the USACE:

- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A) (USEPA, 1989a)
- Guidance for Data Useability in Risk Assessment - Interim Final (USEPA, 1990)
- Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions, Office of Solid Water Management and Emergency Response (OSWER) Directive 9355.0-30 (USEPA, 1991a)
- Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors, OSWER Directive 9285.6-03, March, 1991 (USEPA, 1991b).
- Final Exposure Assessment Guidelines (USEPA, 1992b)
- Supplemental Guidance for Human Health Multimedia Risk Assessments for Hazardous Waste Sites and Permitted Facilties (Cal-EPA, 1992)
- Preliminary Endangerment Assessment Guidance Manual (Cal-EPA, 1994a)
- Recommended Outline for Using Environmental Protection Agency Region IX Preliminary Remediation Goals in Screening Risk Assessments at Military Facilities (Cal-EPA, 1994b)
- Health Effects Assessment Summary Tables (HEAST) (USEPA, 1995)
- Risk Assessment Handbook Volume I: Human Health Evaluation (USACE, 1995a)

- Risk Assessment Handbook Volume II: Environmental Evaluation (USACE, 1995b)
- Selecting Inorganic Constituents as COPC in Risk Assessments at Hazardous Waste Sites and Permitted Facilities (Cal-EPA, 1997)
- Exposure Factors Handbook, Volumes I, II, and III (USEPA, 1997a)
- Risk Assessment Guidance for Superfund (RAGS), Supplemental Guidance – Dermal Risk Assessment (USEPA, 1999b)
- USEPA Region 9 Preliminary Remediation Goals (PRGs) 2000 (USEPA, 2000a)
- Integrated Risk Information System (IRIS) database (USEPA, 2001)

6.1.2 Scope

This baseline HHRA is intended to provide a qualitative and quantitative evaluation of the potential human health risks associated with contaminants present in soils at Sites FTIR-38 Areas 1 and 2 and FTIR-40 Areas 1 and 2. Surface (0 - 1 foot bgs) and subsurface (1 - 10 feet bgs) soil sampling data collected from Site FTIR-38 Area 1 and Site FTIR-40 Areas 1 and 2 were evaluated in this baseline HHRA. For Site FTIR-38 Area 2, only surface soils were evaluated, consistent with the surficial nature of the contamination at this site (please refer to Sections 4.2 and 5.0). Potential migration of COPCs to groundwater and the possible human health impacts associated with groundwater impacts were not quantitatively evaluated in this baseline HHRA, based on depth to groundwater in excess of 176 feet as described in Section 5.0.

6.1.3 Organization of the Human Health Risk Assessment

Section 6.1 - Introduction. This section presents a brief introduction to this document and identifies the objectives and scope of the baseline HHRA.

Section 6.2 - Identification of Chemicals of Potential Concern. This section describes the methods used in the selection of COPCs for evaluation in this baseline HHRA, and summarizes the COPCs identified for Sites FTIR-38 and FTIR-40.

Section 6.3 - Exposure Assessment. This section evaluates the current and potential future land uses for Sites FTIR-38 and FTIR-40; the current and hypothetical future human receptors present; and the exposure pathways and assumptions used in modeling exposures for each receptor.

Section 6.4 - Toxicity Assessment. This section presents the methods used in the development of toxicity information for use in characterizing risks to each receptor

Section 6.5 - Risk Characterization. This section presents the risk characterization methods and results of the baseline HHRA for Sites FTIR-38 and FTIR-40.

Section 6.6 - Analysis of Uncertainty. This section describes the uncertainties associated with the baseline HHRA.

6.2 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

The chemicals identified in soil samples collected from Sites FTIR-38 and FTIR-40 were evaluated in a screening procedure to identify site-specific COPCs. The selection of site-specific COPCs is generally based on specific criteria, including:

- Data selection criteria
- Frequency of detection
- Comparison with laboratory and field blanks
- Comparison with background concentrations
- Essential nutrient status

Each of these criteria was evaluated in the selection of COPCs for Sites FTIR-38 and FTIR-40, as follows.

6.2.1 Data Selection Criteria

All validated chemical data were evaluated for inclusion in the calculation. The evaluation was based on a conservative approach and meeting project data quality objectives. All valid data were treated as follows:

- In the case of a pair of duplicate samples, the highest unqualified values was selected;
- The non-detect result was not used if the sample quantitation limit exceeded the maximum detected concentration in same data sample set (USEPA, 1989a);
- Full values of the detected and one half of non-detect were included.

6.2.2 Frequency of Detection

As per USEPA guidance (USEPA, 1989a), if data from a minimum of 20 samples of a given medium are available, chemicals detected in less than 5 percent of the samples may be eliminated from consideration as COPCs in that medium. If data for less than 20 samples is available, this criterion for COPC identification should not be used (USEPA, 1989a). For all source areas and media, except Site FTIR-38 Area 2 surface soils, data from fewer than 20 samples were available. For Site FTIR-40 Area 2 surface soils, data from more than 20 samples were available for certain inorganic constituents. However, detection frequencies were greater than 5 percent. Therefore, no chemicals were excluded as COPCs based on this criterion.

6.2.3 Comparison with Blanks

If a field sample has detectable concentrations of chemicals that are also detected in associated laboratory method blanks, trip blanks, or equipment rinsate blanks, field sample concentrations are compared to the associated blank concentrations. For chemicals commonly identified as artifacts resulting from laboratory or field procedures (e.g., methylene chloride, acetone, phthalates, etc.), the chemical detected in the field sample may not be considered to be site-related if the detected concentration is less than 10 times the blank concentration. For all other chemicals, the selection criteria used is five times the associated blank concentration (USEPA, 1990). The comparison of field sample concentrations to associated blank concentrations was performed as part of the analytical data validation task (please refer to Section 3.0). Therefore, the chemical concentrations evaluated in this risk assessment were previously evaluated by this criterion.

6.2.4 Comparison with Background Concentrations

Comparison of detected chemical concentrations with background concentrations is appropriate for inorganic chemicals, or organic chemicals that represent 'regional' contaminants, the presence of which are not related to past site activities (USEPA, 1989a). Statistical BUTLs for Fort Irwin soils were previously developed by Parsons ES, as described in Section 4.0. These BUTLs were used in screening inorganic analytes as COPCs for site soils. The maximum detected concentration of each inorganic analyte was compared to its respective BUTL in the selection of COPCs for each source area and medium (Tables 6-1 through 6-11). Derivation of BUTLs was not possible for selenium and silver, due to low detection frequencies for these chemicals (please refer to Section 3.2 of the Final SI Report). Therefore, concentrations of selenium and silver detected in site soils were not screened using this criterion, and were assumed as COPCs for evaluation in the baseline HHRA.

6.2.5 Essential Nutrient Status

Calcium, iron, magnesium, potassium, and sodium are generally considered to be essential nutrients. Essential nutrients are not necessarily considered COPCs, even when media concentrations are a large fraction of what is necessary to induce a toxic response. This is because these concentrations may be beneficial, or even necessary. The following discusses nutritional requirements, typical intakes and toxic levels for these essential nutrients.

6.2.5.1 Calcium. Calcium is critical for bone formation. Other essential functions involving calcium include nerve conductions, muscle contraction, blood clotting, and membrane permeability. The recommended daily allowance (RDA) for calcium in adults is 800 milligrams per day (mg/day). For people between the ages of 11 and 24, the RDA is 1,200 mg/day; while for younger children, the RDA is between 400 and 800 mg/day depending on the age of the child. The average daily intake is 740 mg/day, and ranged from 530 mg/day in women 35 to 50 years old to 1,200 mg/day in boys 12 to 18 years old (U.S. Department of Agriculture [USDA], 1986; 1987). Toxic levels of calcium are not well defined. No toxic effects have been observed in many healthy adults with intakes up to 2,500 mg/day, but high intakes also induce constipation and inhibit the absorption of other essential minerals such as iron and zinc. The National Research Council (NRC) does not recommend calcium intakes much above the RDA (NRC, 1989).

6.2.5.2 Iron. Iron is a constituent of hemoglobin, myoglobin, and several enzymes. The daily iron intake in the U.S. averages 10.7 mg/day, with most iron coming from food, including vitamin-enriched foods (Murphy and Calloway, 1986). The RDA is 15 mg/day for adult women; the RDA for children, the elderly, and adult males is 10 mg/day (NRC, 1989). Adverse effects are unlikely in healthy adults with a daily intake between 25 and 75 milligrams (mg). However, no data are available for the effects of doses in this range for sensitive individuals.

6.2.5.3 Magnesium. Magnesium is an essential component of numerous biochemical and physiological processes. Typical magnesium intakes in the U.S. have declined from about 410 mg/day for all adults in the early 1900s (Welsh and Marston, 1982) to current levels of 330 mg/day for adult men and 210 mg/day for adult women (USDA, 1986; 1987). The RDA is 280 mg/day for adult women, 350 mg/day for adult men, and 90 mg/day for young children. Toxic levels are not well defined, but some insight can be gained from noting that antacids and laxatives such as Maalox™ and Mylanta™ generally are regarded as safe. These products each have about 200 mg of magnesium per teaspoon, with a normal dose of one to two teaspoons. Thus, 200 to 400 mg/day of magnesium, in addition to what is ingested in a normal diet, should be safe.

6.2.5.4 Potassium. Potassium is the principal intercellular cation in the body. Potassium also contributes to the transmission of nerve impulses, the control of skeletal muscle contractions, and the maintenance of normal blood pressure. The RDA for adults is between 1,600 and 2,400 mg/day (NRC, 1989). People who consume large amounts of fruits and vegetables have a higher potassium intake, on the order of 8,000 to 11,000 mg/day, with no apparent adverse effects (NRC, 1989).

6.2.5.5 Sodium. Sodium is the principal cation in the extracellular fluid of the body. In addition, sodium assists in regulating the membrane potential across cells. Estimates of sodium intake based on dietary surveys and analyses of urinary excretion have ranged from 1,800 to 5,000 mg/day (NRC, 1989). The range is much higher than minimum requirements. Concentrations associated with overt toxicity are not well-defined. However, chronic ingestion of high dietary sodium is associated with hypertension.

Essential nutrient status was considered in the evaluation of calcium, iron, magnesium, potassium, and sodium as COPCs for site soils (Tables 6-1 through 6-11).

6.2.6 Summary of Chemicals of Potential Concern

Chemicals detected in soil samples collected from Sites FTIR-38 and FTIR-40 were screened as COPCs for evaluation in this baseline HHRA based on the above criteria. Briefly, inorganic chemicals detected at concentrations below their respective BUTL were excluded as COPCs (Section 6.2.3). In addition, calcium, iron, magnesium, potassium, and sodium were excluded as COPCs based on essential nutrient status (Section 6.2.4). Inorganic chemicals detected at concentrations greater than their respective BUTLs, and all organic chemicals, were included as COPCs for evaluation in the baseline HHRA, consistent with the Workplan (Parsons ES, 1995).

6.2.6.1 Site FTIR-38 Area 1. The selection of COPCs for Site FTIR-38 Area 1 surface and subsurface soils is summarized in Tables 6-1 and 6-2, respectively. Chemicals selected as COPCs for surface soils (0 - 1 foot bgs) include the inorganics aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, and zinc (Table 6-1).

Chemicals selected as COPCs for subsurface soils (1 - 10 feet bgs) include the inorganics aluminum, barium, beryllium, chromium, cobalt, copper, lead, manganese, vanadium, and zinc (Table 6-2).

The COPCs selected for evaluation in the baseline HHRA for Site FTIR-38 Area 1 surface and subsurface soils are summarized in Table 6-3.

6.2.6.2 Site FTIR-38 Area 2. As described in Section 6.1.2, only surface soils were evaluated for Site FTIR-38 Area 2, consistent with the surficial nature of the contamination at this site. The selection of COPCs for Site FTIR-38 Area 2 surface soils is summarized in Table 6-4. Chemicals selected as COPCs for surface soils (0 - 1 foot bgs) include the inorganics aluminum, antimony, arsenic, barium, beryllium, cobalt, copper, lead, manganese, molybdenum, selenium, and zinc (Table 6-4).

The COPCs evaluated in the baseline HHRA for Site FTIR-38 Area 2 surface soils are summarized in Table 6-5.

6.2.6.3 Site FTIR-40 Area 1.1. The selection of COPCs for Site FTIR-40 Area 1.1 surface and subsurface soils is summarized in Tables 6-6 and 6-7, respectively. Chemicals selected as COPCs for surface soils (0 - 1 foot bgs) include the inorganics aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, and zinc; the explosive, 2,4,6-trinitrotoluene; and TRPH (Table 6-6).

Chemicals selected as COPCs for subsurface soils (1 - 10 feet bgs) include the inorganics arsenic, barium, cadmium, copper, lead, manganese, mercury, selenium, silver, and zinc; and TRPH (Table 6-7).

The COPCs selected for evaluation in the baseline HHRA for Site FTIR-40 Area 1.1 surface and subsurface soils are summarized in Table 6-8.

6.2.6.4 Site FTIR-40 Area 2. The selection of COPCs for Site FTIR-40 Area 2 surface and subsurface soils is summarized in Tables 6-9 and 6-10, respectively. Chemicals selected as COPCs for surface soils (0 - 1 foot bgs) include the inorganics arsenic, cadmium, lead, and zinc (Table 6-9).

Chemicals selected as COPCs for subsurface soils (1 - 10 feet bgs) include the inorganics arsenic, barium, cadmium, copper, lead, manganese, mercury, selenium, silver, and zinc; SVOCs including polyaromatic hydrocarbons (PAHs), benzoic acid, bis (2-ethylhexyl) phthalate, and di-n-octyl phthtalate; and TRPH (Table 6-10).

The COPCs evaluated in the baseline HHRA for Site FTIR-40 Area 2 surface and subsurface soils are summarized in Table 6-11.

6.3 EXPOSURE ASSESSMENT

The results of the exposure assessment for Sites FTIR-38 and FTIR-40 are presented in this section. The exposure assessment integrates information on the nature of site contaminant sources, the types of contaminants present, the receptors potentially exposed, and the potential migration and exposure pathways available. The exposure assessment includes the development of a conceptual site model (CSM) for each source area, where appropriate. These steps are discussed below as they relate to the baseline HHRA for Sites FTIR-38 and FTIR-40.

6.3.1 Current and Future Land Uses

The NTC Fort Irwin is not scheduled for base closure, and closure is unlikely in the foreseeable future since Fort Irwin is the NTC for the U.S. Army. Current land usage at NTC Fort Irwin is divided into two major areas: the cantonment area (OU-7) and the range. A third area, Goldstone, was formerly part of Fort Irwin, and is now operated by the National Aeronautics and Space Administration (NASA).

Currently, only areas within the cantonment area (OU-7) are designated residential (i.e., troop and family housing). Based on the Fort Irwin Master Plan, future plans are for the cantonment area to remain the site of residential, administrative, and industrial facilities. Also based on the Fort Irwin Master Plan, plans are for most portions of the range to remain designated as firing range or training (non-fire) areas.

Neither Site FTIR-38 nor Site FTIR-40 is likely to be developed for residential or industrial land uses. Sites FTIR 38 and FTIR 40 are located within Goldstone, and are currently part of the NASA Deep Space Satellite Tracking Station. In addition, the Goldstone area has been designated as 'critical habitat' for the desert tortoise by the United States Fish and Wildlife Service (USFWS). The desert tortoise is a California State and federally-listed threatened species. A consultation with the California Department of Fish and Game and the USFWS is required prior to initiating any type of disruptive activity within a 10-mile radius of this critical habitat. Finally, development of residential or commercial/industrial facilities are most likely to occur where an infrastructure (i.e., roads, power, water supply) is already in place. Sites FTIR 38 and FTIR 40 are approximately 35 miles from the nearest city (Barstow, California). Based on the above, it is highly unlikely that any of the subject sites would be developed for residential or industrial purposes under anticipated future land uses.

6.3.2 Identification of Receptors

The receptors that may be potentially exposed to site contaminants were identified, based on current and potential future land uses and exposure scenarios.

Based on the current and future land uses described in Section 6.3.1, it is highly unlikely that Goldstone, or Sites FTIR-38 and FTIR-40 specifically, would be converted to civilian residential or commercial/industrial land uses. It is also highly unlikely that this area would be used for military training activities. It is possible, however, that a remote testing or industrial facility could be constructed on the site in the future. For this reason, future industrial activities were quantitatively evaluated in this baseline HHRA. In addition, hypothetical future residential receptors (i.e. military personnel) were considered for purposes of evaluating unrestricted future land uses and the appropriateness of institutional controls.

Based on the above, the potential receptors identified for quantitative evaluation in this baseline HHRA include:

- Hypothetical future residents; and
- Future industrial workers.

6.3.3 Evaluation of Potential Exposure Pathways

Completed exposure pathways were identified for each receptor based on anticipated future land uses and site-specific conditions. Direct exposure of hypothetical future residents to soil COPCs is anticipated to occur through incidental ingestion and dermal contact with soil during outdoor activities including gardening and recreation. Inhalation of wind-borne particulates, including indoor dust, derived from site soils is also anticipated to occur. Exposures to both surface and subsurface soils may occur, consistent with the approved Workplan (Parsons ES, 1995), because excavation and construction activities could result in significant disturbance of site soils. Based on the above, hypothetical future residents may be exposed to site COPCs via the following exposure pathways:

- Incidental ingestion of surface and subsurface soils;
- Dermal contact with surface and subsurface soils; and
- Inhalation of wind-borne particulates from surface and subsurface soils

Hypothetical future industrial workers may also be exposed to soils via the above pathways, but on a more limited basis. Potentially completed exposure pathways for the hypothetical future industrial worker include the following:

- Incidental ingestion of surface and subsurface soils;
- Dermal contact with surface and subsurface soils; and
- Inhalation of wind-borne particulates from surface and subsurface soils.

6.3.4 Conceptual Site Model

The CSM provides a summary representation of the potentially exposed receptors and potentially complete exposure pathways. The principle components of the CSM include the following:

- Identification of the contaminant sources
- Evaluation of contaminant migration pathways
- Identification of potential receptors
- Evaluation of potential exposure pathways

A general CSM was developed for Sites FTIR-38 and FTIR-40 based on the receptors selected for evaluation in Section 6.3.2, and the potentially complete exposure pathways identified in Section 6.3.3. The general CSM for Sites FTIR-38 and FTIR-40 is summarized in Figure 6-1. As described in Section 6.3.3, completed exposure pathways were identified for both surface and subsurface soils.

6.3.5 Quantification of Exposures

The quantification of receptor exposures in HHRA is typically based on protective assumptions relative to land use, complete exposure pathways, and calculation of exposure point concentrations. A health-protective assumption underlying all of the dose calculations is that constituent concentrations remain constant over the entire period of exposure.

6.3.5.1 Exposure Point Concentration. Calculation of the exposure point concentration was based on both measured concentrations (i.e., hits) and non-detect results. When a dataset contained non-detect results, one-half the sample quantitation limit was assumed for that sample. The exposure point concentrations were estimated as either the maximum or the 95 percent upper confidence limit (UCL) of the arithmetic mean concentration detected in site media. If the calculated 95 percent UCL of the mean concentration was greater than the maximum concentration detected, the maximum value was assumed as the exposure point concentration; otherwise the 95 percent UCL was used.

The 95 percent UCL of the arithmetic mean concentration was calculated based on a lognormal distribution, according to the methods described in Gilbert (1987). Four-point Lagrangian interpolation and an H table from Gilbert (1987) were used to determine H values for use in the UCL calculation. The equation for calculating the UCL of the arithmetic mean for a lognormal distribution (Gilbert, 1987) is given by:

$$UCL = e^{\bar{x}+0.5s^2+sH/\sqrt{n-1}}$$

where:

UCL	= upper confidence limit
e	= constant (base of the natural log, equal to 2.718)
$\bar{x}$	= mean of the transformed data
s	= standard deviation of the transformed data
H	= H-statistic (Gilbert, 1987)
n	= number of samples

Exposure point concentrations for Sites FTIR-38 (Areas 1 and 2) and FTIR-40 (Areas 1 and 2) are presented in Tables 6-12 through 6-18.

6.3.5.2 Exposure Dose Calculation. The algorithms for calculating the exposure dose for each pathway are presented below. For potential carcinogenic effects, exposure doses were averaged over a lifetime; doses for potential non-carcinogenic effects were averaged over the actual exposure period (USEPA, 1989a).

For hypothetical future residents (i.e. military personnel), the algorithm for calculating exposure due to incidental ingestion of soil is the following:

$$Dose\ (mg/kg\text{-}d) = \frac{((Cs \times IR_{adult} \times EF \times ED_{adult} \times UC)/BW_{adult}) + ((Cs \times IR_{child} \times EF \times ED_{child} \times UC)/BW_{child}))}{AT}$$

where:

Cs	=	exposure point concentration in soil (mg/kg)
IR_{adult}	=	ingestion rate of soil for adults (mg/day)
EF	=	exposure frequency for adults/children (days/year)
ED_{adult}	=	exposure duration for adults (years)
BW_{adult}	=	body weight for adults (kilograms [kg])
UC	=	unit conversion (10^{-6} kg/mg)
IR_{child}	=	ingestion rate of soil for children (mg/day)
ED_{child}	=	exposure duration for children (years)
BW_{child}	=	body weight for children (kg)
AT	=	averaging time (days)

For hypothetical future residents (i.e. military personnel), the algorithm for calculating the exposure due to dermal contact with soil is the following:

$$Dose\ (mg/kg\text{-}day) = \frac{(Cs \times SA_{adult} \times AF_{adult} \times EF \times ED_{adult})/BW_{adult}) + (Cs \times SA_{child} \times AF_{child} \times EF \times ED_{child})/BW_{child}) \times ABS \times UC}{AT}$$

where:

Cs = soil exposure point concentration (mg/kg)

SA_{adult} = skin surface area exposed for adults (square centimeters[cm^2]/day)

AF_{adult} = soil to skin adherence factor for adults (mg/cm^2)

EF = exposure frequency (days/year)

ED_{adult} = exposure duration (years)

BW_{adult} = body weight for adults (kg)

SA_{child} = skin surface area exposed for adults (cm^2/day)

AF_{child} = soil to skin adherence factor for adults (mg/cm^2)

EF = exposure frequency (days/year)

ED_{child} = exposure duration (years)

BW_{child} = body weight for adults (kg)

ABS = absorption fraction of chemical from soil (unitless)

UC = unit conversion (10^{-6} kg/mg)

AT = averaging time (days)

For hypothetical future residents (i.e. military personnel), the algorithm for calculating exposure due to inhalation of particulates from soil is the following:

$$Dose\ (mg/kg\text{-}d) = \frac{((Cs \times (1/PEF) \times InhR_{adult} \times EF \times ED_{adult})/BW_{adult}) + ((Cs \times (1/PEF) \times InhR_{child} \times EF \times ED_{child})BW_{child})}{AT}$$

where:

Cs = exposure point concentration in soil (mg/kg)

PEF = particulate emission factor (cubic meters [m^3]/kg)

$InhR_{adult}$ = inhalation rate for adults (m^3/day)

EF = exposure frequency (day/year)

ED_{adult} = exposure duration for adults (day/year)

BW_{adult} = body weight for adults (kg)

$InhR_{child}$ = inhalation rate for children (m^3/day)

ED_{child} = exposure duration for children (day/year)

BW_{child} = body weight for children (kg)

AT = averaging time (days)

For future industrial workers, the algorithm for calculating the exposure dose due to incidental ingestion of soil is the following:

$$Dose\ (mg/kg\text{-}day) = \frac{Cs \times IR \times EF \times ED \times UC}{BW \times AT}$$

where:

Cs = soil exposure point concentration (mg/kg)

IR = ingestion rate of soil (mg/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

UC = unit conversion (10^{-6} kg/mg)

BW = body weight (kg)

AT = averaging time (days)

For future industrial workers, the algorithm for calculating the exposure due to dermal contact with soil is the following:

$$Dose\ (mg/kg\text{-}day) = \frac{Cs \times SA \times AF \times ABS \times EF \times ED \times UC}{BW \times AT}$$

where:

Cs	=	soil exposure point concentration (mg/kg)
SA	=	skin surface area exposed (cm^2/day)
AF	=	soil to skin adherence factor (mg/cm^2)
ABS	=	absorption fraction of chemical from soil (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
UC	=	unit conversion (10^{-6} kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days)

For future industrial workers, the algorithm for calculating exposure due to inhalation of particulates from soil is the following:

$$Dose\ (mg/kg\text{-}d) = \frac{(Cs \times (1/PEF_{normal}) \times InhR \times EF_{normal} \times ED) + (Cs \times (1/PEF_{windy}) \times InhR \times EF_{windy} \times ED)}{BW \times AT}$$

where:

Cs	=	exposure point concentration in soil (mg/kg)
PEF_{normal}	=	particulate emission factor under normal conditions (m^3/kg)
InhR	=	inhalation rate (m^3/day)
EF_{normal}	=	exposure frequency during normal air particulate conditions (day/year)
ED	=	exposure duration (years)
PEF_{windy}	=	particulate emission factor under windy conditions (m^3/kg)
EF_{windy}	=	exposure frequency during windy conditions (day/year)
BW	=	body weight (kg)
AT	=	averaging time (days)

6.3.5.3 **Exposure Parameters and Assumptions.**

The parameters and assumptions used in modeling exposure doses for the hypothetical future resident are summarized in Table 6-19. Standard default assumptions published by the USEPA and Cal-EPA were used to calculate daily exposure doses for hypothetical future residents. Exposure doses for residential receptors were based on a total exposure duration of 30 years, assuming exposures for 6 years as a child and 24 years as an adult.

The parameters and assumptions used in modeling exposure doses for future industrial workers are summarized in Table 6-20. The majority of exposure assumptions that were used to calculate doses for future industrial workers are based on standard default assumptions published by the USEPA and Cal-EPA. The exceptions include: (1) a PEF_{windy} value of 1.6×10^7 m^3/kg (corresponding to a respirable particulate concentration of 61 micrograms per cubic meter[$\mu g/m^3$]) which represents the highest annual average value compiled over 4 years by the Mojave Desert Air Quality Management District in Victorville, California (Parsons ES, 1995); and (2) an EF_{windy} value of 50 days per year, representing an assumed number of days that particularly windy conditions occur

6.4 TOXICITY ASSESSMENT

The toxicity assessment involves a critical review and interpretation of toxicology data from epidemiological, clinical, animal, and *in vitro* studies. The review of toxicology data ideally determines both the nature of the health effects associated with a particular chemical, and the probability that a given dose of a chemical could result in an adverse health effect. Toxicology information considered important for quantitative risk assessment includes:

- The potential for carcinogenic health effects
- The potential for chronic noncarcinogenic, adverse health effects
- The ability to cause short-term, acute effects
- The ability to affect reproduction

For carcinogens, it is assumed that no threshold dose exists, and that any dose may induce cancer. The probability of cancer development is described by the slope of the dose response curve. The doses from various known or suspected carcinogens are assumed to be additive. For noncarcinogens, it is assumed that a dose exists below which no adverse health effects are seen (i.e., threshold dose). Compounds with short-term, acute effects are also generally considered to have a threshold dose. Compounds that affect reproduction are considered to have threshold doses unless the mechanism of action of the compound has been confirmed as one for which no threshold exists.

For purposes of conducting quantitative HHRAs, toxic effects of chemicals are generally categorized as carcinogenic or noncarcinogenic. The carcinogenic potential of a chemical is used in a quantitative estimate of potential cancer risk. The potential for a chemical to produce noncarcinogenic adverse health effects is used in a quantitative estimate of noncarcinogenic hazard.

6.4.1 Carcinogenic Effects of Chemicals of Potential Concern

The cancer slope factor (CSF) is the toxicity value used to quantitatively express the carcinogenic potential of cancer-causing constituents. The slope factor is expressed in units of $(mg/kg\text{-}day)^{-1}$ and represents the cancer risk per unit daily intake of carcinogenic chemical. The CSF represents the upper 95 percent confidence interval of the slope of the dose response curve. The 95 percent upper confidence interval value assures a safety factor to protect the most sensitive receptors. The product of the CSF and the exposure dose is an estimate of the risk of developing cancer from exposure to the compound of interest. Current scientific practice regards carcinogens as having additive doses and not having a threshold dose

6.4.2 Noncarcinogenic Effects of Chemicals of Potential Concern

The reference dose (RfD) is the toxicity value used to quantitatively express the potential for a chemical to produce noncarcinogenic effects. The RfD is expressed in units of mg/kg-day and represents a daily intake of contaminant per kilogram of body weight that is not sufficient to cause the threshold effect of concern for the contaminant. Exposure doses that are above the RfD, or the threshold dose for noncarcinogens, could potentially cause adverse health effects.

The RfD is usually based on a no-observable-adverse-effect-level (NOAEL) derived from animal studies. An uncertainty factor is typically incorporated into the RfD, resulting in a reduction in the numerical value (i.e., resulting in a more protective toxicity value). The uncertainty factor is intended to account for uncertainties associated with (1) the extrapolation of dose-response data from animal studies to humans; (2) the existence of sensitive subpopulations within the human population; and (3) the quality of the laboratory study and database from which the dose response information is derived. Confidence in the RfD is judgmental, based on USEPA review groups and the supporting quality of the database. Chemical-specific RfDs do not account for the potential effects of chemical mixtures.

6.4.3 Pathway-Specific and Chemical-Specific Assumptions

The toxicity values used to estimate risks for hypothetical future residents and future industrial workers are presented in Table 6-21. Oral and inhalation toxicity values were generally available for most COPCs identified for Sites FTIR-38 and FTIR-40. However, the USEPA has not established toxicity values based on the dermal route of administration. For evaluating estimated exposure doses for the dermal pathway, oral toxicity values were used without modification, as specified in the approved Workplan (Parsons ES, 1995).

Following are several chemical-specific assumptions used in the toxicity assessment for this baseline HHRA.

6.4.3.1 Beryllium, Cadmium, and Chromium. Oral or dermal CSFs are not currently available for beryllium, cadmium, or chromium. The available toxicology information indicates that beryllium, cadmium, and chromium are carcinogenic by the inhalation route of exposure. However, available data does not support a presumption that these chemicals are carcinogenic by the oral or dermal routes of exposure. Therefore, the potential carcinogenic effects of beryllium, cadmium, and chromium were not evaluated for exposure pathways other than the inhalation route. It should be noted that the noncarcinogenic toxicity values (i.e., RfDs) available for these chemicals are based on the oral route of administration. Therefore, the potential noncarcinogenic effects attributable to exposure pathways other than inhalation (i.e., oral and dermal) were evaluated for these chemicals.

6.4.3.2 Lead. Currently there are no toxicity values (i.e., CSFs or RfDs) available for the quantitative evaluation of potential human health impacts associated with exposures to lead in soils. Therefore, lead concentrations measured in soil were evaluated using Cal-EPA's *Lead Risk Assessment Spreadsheet* [Lead Spread 7; Bloodpb7.xls], which models contributions of both ambient and site-related lead exposures to the total blood-lead concentration. Exposures are modeled in units of micrograms lead per deciliter of blood (µg/dl) and are compared to an acceptable blood-lead concentration of 10 ug/dl. The results of blood-lead screening are presented in Section 6.5.2.

6.4.3.3 Mercury. Mercury was identified as a COPC for Site FTIR-40 (Areas 1.1 and 2). For evaluating the noncarcinogenic hazards associated with mercury, toxicity values for the inorganic form (mercuric chloride) were used. Toxicity values have been developed for the organic form (methyl mercury). However, there is no evidence to suggest that organic mercury is a COPC for Site FTIR-40. Potential anthropogenic sources of metals at the site are believed to be associated with firing range activities and metal debris, suggesting that inorganic forms of the metals predominate.

6.4.3.4 Polycyclic Aromatic Hydrocarbons. The USEPA has not yet established a national policy for assigning cancer potencies to different PAHs. In the interim, USEPA Region IX has set a regional policy based on the recommendation of the Environmental Criteria Assessment Office (ECAO) to use a set of toxicity equivalency factors (TEFs) to calculate a "benzo[a]pyrene equivalent" concentration for PAH mixtures. The toxicities associated with the various carcinogenic PAH COPCs detected in site soils were assigned using these potency equivalency factors (Table 6-21).

6.4.3.5 Total Petroleum Hydrocarbons. Currently there are no toxicity values (i.e., CSFs or RfDs) available for the quantitative evaluation of potential human health impacts associated with exposures to total petroleum hydrocarbons (TPH). According to the *Recommended Outline for Using Environmental Protection Agency Region IX Preliminary Remediation Goals in Screening Risk Assessments at Military Facilities* (Cal-EPA, 1994b), TPH measurement should not be used at any level of risk assessment. This guidance states that the principle toxic constituents (i.e., benzene, toluene, ethylbenzene, xylenes [BTEX], and PAHs) of hydrocarbon fuels should be evaluated. Where available, sampling results for these constituents were used in the quantitative evaluation of risks associated with non-specific petroleum hydrocarbons such as TRPH.

6.4.4 Toxicity Information Sources

The primary sources of toxicity values used in this baseline HHRA were the IRIS, 2001 compiled by USEPA, and the HEAST (USEPA, 1995). The Agency for Toxic Substance and Disease Registry (ATSDR) profiles for selected compounds were also reviewed. Toxicology profiles for the COPCs evaluated in this baseline HHRA are presented in Appendix L.

6.5 RISK CHARACTERIZATION

This section presents the methods and results of the risk characterization performed for the baseline HHRA. Risk characterization involves the integration of exposure estimates developed as part of the exposure assessment with dose-response information (toxicity values) developed as part of the toxicity assessment. The result is a quantitative estimate of the likelihood of chronic health effects, in the form of carcinogenic risks or noncarcinogenic hazards. The carcinogenic risk estimate is based on the premise that carcinogenicity is a non-threshold effect (i.e., that even at the lowest dose there is some potential to develop carcinogenic effects). In contrast, the noncarcinogenic hazard estimate is based on the premise that for noncarcinogens there is a threshold dose below which adverse health effects will not occur.

6.5.1 Methods

Following are the methods that were used in the evaluation of carcinogenic risks and noncarcinogenic hazards for current/future military personnel and hypothetical future industrial workers potentially exposed to site-derived soil contaminants.

6.5.1.1 Carcinogenic Risks. Baseline human health risks were evaluated separately for carcinogenic effects and noncarcinogenic effects. The incremental lifetime cancer risk (ILCR) is an estimate of the increased risk of cancer due to lifetime exposure, at apportioned average daily doses, to constituents detected in each medium at the site. For current/future military personnel and hypothetical future industrial workers, risks were calculated as the product of the exposure dose and the carcinogenic toxicity value, the CSF (USEPA, 1989a).

The equation for calculating carcinogenic risks is as follows:

$$\text{ILCR (unitless)} = \text{CSF} \times \text{Dose}$$

where:

CSF = Cancer slope factor (mg/kg-day)-1

Dose = Exposure dose (mg/kg-day)

Cancer risks from multiple COPCs were assumed to be additive, and were summed to estimate a total cumulative ILCR for all carcinogenic site contaminants The resulting risk estimates are an indication of the increased risk, above that applying to the general population, which may result from the exposures assumed for each scenario. The risk estimate is an upper bound estimate of risk, because of the protective assumptions used in the development of toxicity values and exposure estimates. Therefore, it is probable that the actual risks associated with potential exposures to site contaminants are lower than estimated risks.

6.5.1.2 Noncarcinogenic Hazards. To evaluate noncarcinogenic health effects due to potential exposures to site COPCs, a hazard quotient (HQ) was calculated for each COPC. The HQ was calculated as the ratio of the exposure dose to the RfD (USEPA, 1989a).

The equation for calculating noncarcinogenic hazards is as follows:

$$HQ\ (unitless) = \frac{Dose}{RfD}$$

where:

Dose = Exposure dose (mg/kg-day)
RfD = Reference dose (mg/kg-day)

A hazard quotient greater than 1.0 indicates that the estimated exposure dose for that COPC may exceed acceptable health-protective levels for noncarcinogenic effects. Although an HQ of less than 1.0 suggests that noncarcinogenic health effects should not occur, an HQ of slightly greater than 1.0 is not necessarily an indication that adverse effects will occur.

The individual HQs for site COPCs were summed to produce a total cumulative hazard estimate, the HI. If the total HI estimate is less than 1.0, then no noncarcinogenic chronic health effects are expected to occur. If the total HI estimate is greater than 1.0, then adverse health risks are considered possible.

Sites with an estimated cumulative cancer risk between 1.0 x 10^{-6} and 1.0 x 10^{-4} and an noncancer HI less than 1.0 are within USEPA's risk management range and may be considered for no further action depending upon site-specific conditions and future land uses (USEPA, 1991a). Sites that are associated with a cumulative cancer risk or noncancer HI greater than these criteria are generally considered for further action including potential evaluation of remedial alternatives (USEPA, 1991a).

6.5.2 Results

The results of the risk characterization performed for Sites FTIR-38 and FTIR-40 are described in the following subsections. Detailed carcinogenic risk and noncarcinogenic hazard calculations for each medium (i.e., surface or subsurface soil) and receptor are presented in Appendix M. Summary results for Sites FTIR-38 and FTIR-40 are presented in Tables 6-22 and 6-23, respectively.

6.5.2.1 Site FTIR-38. The risk characterization results for Site FTIR-38 Areas 1 and 2 are presented in Sections 6.5.2.1.1 and 6.5.2.1.2, respectively.

6.5.2.1.1 Site FTIR-38 Area 1. The total cumulative cancer risk and noncancer hazard estimates for hypothetical future residents exposed to Site FTIR-38 Area 1 surface soils were 4.0 x 10^{-5} and 0.5, respectively (Table 6-22). The total cumulative cancer risk and noncancer hazard estimates for future industrial workers exposed to Site FTIR-38 Area 1 surface soils were 7.1 x 10^{-6} and 0.28, respectively (Table 6-22). The primary COPCs contributing to the risk estimates were arsenic and chromium. It is worth noting that the maximum concentrations of arsenic and chromium detected in surface soils were less than two times their respective BUTLs (Table 6-1). The cancer risk and noncancer HI estimates for Site FTIR-38 Area 1 surface soils are within USEPA's risk management range of 1.0 x 10^{-6} to 1.0 x 10^{-4}, and HI less than 1.0. In addition, blood-lead concentrations estimated using Cal-EPA's *Lead Risk Assessment Spreadsheet* [Lead Spread 7; Bloodpb7.xls], and based on the maximum lead concentration detected in Site FTIR-38 Area 1 surface soils (190 mg/kg), were less than 10 ug/dl for both residential receptors and industrial workers. Based on these results, no constituents of concern (COCs) were identified for Site FTIR-38 Area 1 surface soils for evaluation in the FS.

The total cumulative cancer risk and noncancer hazard estimates for hypothetical future residents exposed to Site FTIR-38 Area 1 subsurface soils were 1.6 x 10^{-7} and 0.51, respectively (Table 6-22). The total cumulative cancer risk and noncancer hazard estimates for future industrial workers exposed to Site FTIR-38 Area 1 subsurface soils were 1.3 x 10^{-6} and 0.28, respectively (Table 6-22). The primary COPC contributing to the risk estimates was chromium. It is worth noting that the maximum concentration of chromium detected in subsurface soils was less than two times its BUTLs (Table 6-2). The cancer risk and noncancer HI estimates for Site FTIR-38 Area 1 subsurface soils are within USEPA's risk management range of 1.0 x 10^{-6} to 1.0 x 10^{-4}, and HI less than 1.0. In addition, blood-lead concentrations estimated using Cal-EPA's *Lead Risk Assessment Spreadsheet* [Lead Spread 7; Bloodpb7.xls], and based on the maximum lead concentration detected in Site FTIR-38 Area 1 subsurface soils (105 mg/kg), were less than 10 ug/dl for both residential receptors and industrial workers. Based on these results, no COCs were identified for Site FTIR-38 Area 1 subsurface soils for evaluation in the FS.

6.5.2.1.2 Site FTIR-38 Area 2. The total cumulative cancer risk and noncancer hazard estimates for hypothetical future residents exposed to Site FTIR-38 Area 2 surface soils were 2.2 x 10^{-5} and 0.41, respectively (Table 6-22). The total cumulative cancer risk and noncancer hazard estimates for future industrial workers exposed to Site FTIR-38 Area 2 surface soils were 3.3 x 10^{-6} and 0.37, respectively (Table 6-22). The primary COPC contributing to the risk estimate was arsenic. It is worth noting that the maximum concentration of arsenic detected in surface soils was less than two times its BUTL (Table 6-4). The cancer risk and noncancer HI estimates for Site FTIR-38 Area 2 surface soils are within USEPA's risk management range of 1.0 x 10^{-6} to 1.0 x 10^{-4}, and HI less than 1.0. However, blood-lead concentrations estimated using Cal-EPA's *Lead Risk Assessment Spreadsheet* [Lead Spread 7; Bloodpb7.xls], and based on the maximum lead concentration detected in Site FTIR-38 Area 2 surface soils (6,430 mg/kg), exceeded 10 ug/dl for both residential receptors and industrial workers. Based on these results, lead was selected as a COC for Site FTIR-38 Area 2 surface soils for further evaluation in the FS.

Site FTIR-38 Area 2 subsurface soils were not evaluated, consistent with the surficial nature of the contaminant source at this site (please refer to Section 4.2).

6.5.2.1 Site FTIR-40. The risk characterization results for Site FTIR-40 Areas 1 1 and 2 are presented in Sections 6.5.2.2.1 and 6.5.2.2.2, respectively.

6.5.2.2.1 Site FTIR-40 Area 1.1. The total cumulative cancer risk and noncancer hazard estimates for hypothetical future residents exposed to Site FTIR-40 Area 1.1 surface soils were 2.7×10^{-5} and 2.5, respectively (Table 6-23). The total cumulative cancer risk and noncancer hazard estimates for future industrial workers exposed to Site FTIR-40 Area 1.1 surface soils were 5.4×10^{-6} and 0.48, respectively (Table 6-23). The primary COPCs contributing to the cancer risk estimates were arsenic and chromium. The maximum concentration of arsenic detected in surface soils was less than two times its BUTL, and the maximum concentration of chromium was approximately three times its BUTL (Table 6-6). The cancer risk estimates for Site FTIR-40 Area 1.1 surface soils are within USEPA's risk management range of 1.0×10^{-6} to 1.0×10^{-4} for cancer risk. However, the noncancer HI estimate for hypothetical future residents (HI = 2.5) exceeds a hazard criterion of 1.0. Of the COPCs contributing to the HI estimate, the primary contributor (copper) is associated with a chemical-specific HQ equal to 1.2 (Table H-14). Therefore, even on a target organ-specific basis, the maximum concentration of copper detected in surface soils (12,900 mg/kg) results in a chemical-specific HQ in excess of the HI criterion of 1.0. It is extremely unlikely, however, that Site FTIR-40 Area 1.1 would ever be developed for residential land use. Furthermore, the total noncancer HI for future industrial workers is less than 1.0. Based on the above, copper was not identified as a human health COC for Site FTIR-40 Area 1.1 surface soils. Blood-lead concentrations estimated using Cal-EPA's *Lead Risk Assessment Spreadsheet* [Lead Spread 7; Bloodpb7.xls], and based on the maximum lead concentration detected in Site FTIR-40 Area 1.1 surface soils (38,400 mg/kg), exceeded 10 ug/dl for both residential receptors and industrial workers. Therefore, lead was selected as a COC for Site FTIR-40 Area 1.1 surface soils for further evaluation in the FS.

The total cumulative cancer risk and noncancer hazard estimates for hypothetical future residents exposed to Site FTIR-40 Area 1.1 subsurface soils were 2.5×10^{-5} and 0.32, respectively (Table 6-23). The total cumulative cancer risk and noncancer hazard estimates for future industrial workers exposed to Site FTIR-40 Area 1.1 subsurface soils were 3.7×10^{-6} and 0.14, respectively

(Table 6-23). The primary COPC contributing to the risk estimates was arsenic. It is worth noting that the maximum concentration of arsenic detected in subsurface soils was less than two times its BUTL (Table 6-7). The cancer risk and noncancer HI estimates for Site FTIR-40 Area 1.1 subsurface soils are within USEPA's risk management range of 1.0 x 10^{-6} to 1.0 x 10^{-4}, and HI less than 1.0. In addition, blood-lead concentrations estimated using Cal-EPA's *Lead Risk Assessment Spreadsheet* [Lead Spread 7; Bloodpb7.xls], and based on the maximum lead concentration detected in Site FTIR-40 Area 1.1 subsurface soils (154 mg/kg), were less than 10 ug/dl for both residential receptors and industrial workers. Based on these results, no COCs were identified for Site FTIR-40 Area 1.1 subsurface soils for evaluation in the FS.

6.5.2.2.2 Site FTIR-40 Area 2. The total cumulative cancer risk and noncancer hazard estimates for hypothetical future residents exposed to Site FTIR-40 Area 2 surface soils were 2.5 x 10^{-5} and 0.13, respectively (Table 6-23). The total cumulative cancer risk and noncancer hazard estimates for future industrial workers exposed to Site FTIR-40 Area 2 surface soils were 6.3 x 10^{-6} and 0.02, respectively (Table 6-23). The primary COPC contributing to the cancer risk estimate was arsenic. However, the maximum concentration of arsenic detected in surface soils was less than two times its BUTL (Table 6-9). The cancer risk and noncancer HI estimates for Site FTIR-40 Area 2 surface soils are within USEPA's risk management range of 1.0 x 10^{-6} to 1.0 x 10^{-4}, and HI less than 1.0. In addition, blood-lead concentrations estimated using Cal-EPA's *Lead Risk Assessment Spreadsheet* [Lead Spread 7; Bloodpb7.xls], and based on the maximum lead concentration detected in Site FTIR-40 Area 2 surface soils (259 mg/kg), were less than 10 ug/dl for both residential receptors and industrial workers. Based on these results, no COCs were identified for Site FTIR-40 Area 2 surface soils for evaluation in the FS.

The total cumulative cancer risk and noncancer hazard estimates for hypothetical future residents exposed to Site FTIR-40 Area 2 subsurface soils were 3.1 x 10^{-5} and 0.23, respectively (Table 6-23). The total cumulative cancer risk and noncancer hazard estimates for future industrial workers exposed to Site FTIR-40 Area 2 subsurface soils were 7.8 x 10^{-6} and 0.1, respectively (Table 6-23). The primary COPCs contributing to the risk estimates were arsenic and benzo(a)pyrene. It is worth noting that the maximum concentration of arsenic detected in subsurface soils was less than two times its BUTL (Table 6-10). The cancer risk and noncancer HI estimates for Site FTIR-40 Area 2 subsurface soils are within USEPA's risk management range of 1.0×10^{-6} to 1.0×10^{-4}, and HI less than 1.0. In addition, blood-lead concentrations estimated using Cal-EPA's *Lead Risk Assessment Spreadsheet* [Lead Spread 7; Bloodpb7.xls], and based on the maximum lead concentration detected in Site FTIR-40 Area 2 subsurface soils (133 mg/kg), were less than 10 ug/dl for both residential receptors and industrial workers. Based on these results, no COCs were identified for Site FTIR-40 Area 2 subsurface soils for evaluation in the FS.

6.6 UNCERTAINTY ANALYSIS

The presence of uncertainty is inherent in the risk assessment process. Generally, uncertainties in the risk assessment typically result from limitations in the available methods, information, and data used in the following:

- Characterization of contaminant sources
- Identification of site COPCs
- Evaluation of potential exposure scenarios and pathways
- Toxicity assessment
- Risk characterization

The uncertainties associated with each of these steps as they relate to the baseline HHRA for Sites FTIR-38 and FTIR-40 are described below.

6.6.1 Characterization of Contaminant Sources

There is a degree of uncertainty in the characterization of contaminant sources, since it is not possible to sample an entire site. The site investigations were based on site histories, known releases, and physical characteristics (e.g., the presence of waste materials or topographic anomalies). The nature of these site investigations focused on known or suspected sources of contamination. While it is believed that sufficient samples were collected to characterize the nature and extent of contamination at the sites, it is possible that areas not sampled may have also contained contaminants. However, sample locations were generally chosen such that they represented the area with the greatest potential to detect contaminants, if present.

A total of 5 surface soil samples were collected from Site FTIR-38 Area 1 and analyzed for inorganic constituents, nitroaromatics/nitroamines, nitrogen-ammonia, nitrate/nitrite, and nitroglycerin. Surface soils samples were *not* analyzed for other chemicals including VOCs, SVOCs, pesticides/polychlorinated biphenyl (PCBs), dioxins/furans, or petroleum hydrocarbons. However, these constituents are not anticipated to be present based on previous use of the site as a small arms and mortar range, and waste materials found during SI activities were limited to metal debris. Only two subsurface soil samples were collected from Site FTIR-38 Area 1 and analyzed. However, limited subsurface sampling is consistent with the surficial nature of the contaminantion sources, and only low concentrations of inorganic constituents were detected at this location.

A total of 22 surface soil samples were collected from Site FTIR-38 Area 2. Samples were analyzed for inorganic constituents, nitroaromatics/nitroamines, nitrogen-ammonia, nitrate/nitrite, and nitroglycerin. Again, surface soils samples were *not* analyzed for other chemicals including VOCs, SVOCs, pesticides/PCBs, dioxins/furans, or petroleum hydrocarbons. However, these constituents are not anticipated to be present based on previous use of the site as a small arms range, and the primary waste materials found during SI activities were spent rounds of 50 caliber ammunition. No subsurface soil samples were collected from Site FTIR-38 Area 2; however, this is consistent with the surficial nature of the contaminantion sources present.

A total of 13 surface soil samples were collected from Site FTIR-40 Area 1.1 and analyzed for inorganic constituents, nitroaromatics/nitroamines, nitrogen-ammonia, nitrate/nitrite, nitroglycerin, and petroleum hydrocarbons. Surface soils samples were *not* analyzed for other chemicals including VOCs, SVOCs, pesticides/PCBs, or dioxins/furans. However, these constituents are not anticipated to be present based on previous use of the site as part of the Mojave Anti-Aircraft Range, and waste materials found during SI activities were limited to metal debris and asphalt. Only two subsurface soil samples were collected from Site FTIR-40 Area 1.1 and analyzed. However, limited subsurface sampling is consistent with the surficial nature of the contaminantion sources, and only inorganic constituents and low concentrations of 2,4,6-trinitrotoluene and TRPH were detected in surface soil samples collected from this location.

A total of 10 surface soil samples and 16 subsurface soil samples were collected from Site FTIR-40 Area 2 and analyzed. Surface soil samples were analyzed for inorganic constituents in support of the Phase II Validation Study. Subsurface soil samples were analyzed for inorganics, VOCs, SVOCs, and petroleum hydrocarbons, consistent with the presence of a septic tank at this location. Low concentrations of inorganic constituents; SVOCs including PAHs, benzoic acid, and two phthtalates; and TRPH were detected in subsurface soil samples collected near the septic tank. The number of samples collected and analyzed is believed to be sufficient to characterize the site, and the sampling locations were selected to represent the highest probability of detecting contaminants.

6.6.2 Identification of Site Chemicals of Potential Concern

The process used in the selection of site COPCs may also introduce a degree of uncertainty in the baseline HHRA. However, protective assumptions were used in the selection of site COPCs. Chemicals selected for quantitative evaluation in the HHRA included all organic chemicals, and inorganic chemicals (other than essential nutrients) detected at concentrations above BUTLs established for Fort Irwin soils. For selenium and silver, BUTLs could not be established. To be protective, therefore, these chemicals were carried through the risk assessment as COPCs.

6.6.3 Exposure Assessment

Because the exposure assessment is based on the estimation of potential rather than actual exposures, there is a degree of uncertainty in the dose estimate. The evaluation of residential and industrial receptors under hypothetical future land use conditions was included in this HHRA to provide a basis for assessing future land uses. However, Sites FTIR 38 and FTIR 40 are located within Goldstone, and are currently part of the NASA Deep Space Satellite Tracking Station. In addition, the Goldstone area has been designated as 'critical habitat' for the desert tortoise by the USFWS. Therefore, neither of these sites is likely to be developed for residential or industrial land uses. Finally, protective exposure assumptions and maximum or 95 percent UCL concentrations were used in estimating exposure doses for hypothetical future residential and industrial receptors. Consequently, the exposure doses presented in this baseline HHRA most likely represent overestimates.

6.6.4 Toxicity Assessment

There are also sources of uncertainty in the derivation of toxicity values (i.e., cancer slope factors and RfDs) used to quantify risks. Generally, the toxicity values that were used represent upper bound estimates, and incorporate uncertainty factors for extrapolation from animal data to humans, differences in individual sensitivity within populations, and the overall confidence in the dataset. Furthermore, the use of oral slope factors or oral RfDs for dermal toxicity values do not correct for differences in absorption and metabolism between the oral and dermal routes. Because the toxicity values established by USEPA are based on NOAEL concentrations and incorporate uncertainty factors, they are generally considered to be protective. The use of conservative toxicity values in the risk estimate tends to overestimate actual risks.

The risks associated with TPH were not evaluated quantitatively, because toxicity values are currently unavailable for these materials. However, analyses were performed for individual hydrocarbons which detect the most toxic constituents such as BTEX and PAHs. Toxicity values are available for these constituents, and they were evaluated quantitatively in this baseline HHRA, when appropriate.

6.6.5 Risk Characterization

The different sources of uncertainty previously described are incorporated in the risk estimate. Because the majority of these uncertainties err on the conservative side, the risk estimate is considered to be protective. Furthermore, a 1.0×10^{-6} risk level does not equate to an actual cancer incidence of one-in-one-million for substances that may cause cancer. The risk assessment process uses animal data to predict the probability of humans developing cancer over a 70-year lifetime. The estimated risks presented in this HHRA represent upper bound estimates; the actual risks are anticipated to be less.

7.0 PHASE II ECOLOGICAL VALIDATION STUDY

This section presents the results and analysis of a Phase II Ecological Validation Study conducted for NTC Fort Irwin Sites FTIR-38 and FTIR-40. The Phase II Ecological Validation Study was initiated following the estimation of hazard estimates in excess of 1.0 for the Mojave ground squirrel during the Phase I quantitative portion of the Phase I Ecological Risk Assessment (Phase I ERA) for Sites FTIR-38 and FTIR-40 (Montgomery Watson, 1998). At the request of the DTSC, the Army conducted plant tissue sampling in April 1999 to be used in the validation of exposure dose concentrations for the Mojave ground squirrel. Plant tissue data collected from Sites FTIR-38 and FTIR-40, in conjunction with collocated soils data and site-specific reference data, were evaluated in this Phase II Ecological Validation Study. The results of this Phase II Ecological Validation Study will be used in conjunction with the results of the baseline HHRA for Sites FTIR-38 and FTIR-40 to develop a decision regarding whether or not current concentrations of chemicals on site require further action, further evaluation, or remediation.

7.1 INTRODUCTION

As described in Section 1.2, Sites FTIR-38 and FTIR-40 each contain two different source areas that are geographically distinct: FTIR-38 Area 1, FTIR-38 Area 2, FTIR-40 Area 1, and FTIR-40 Area 2. Since the Phase I ERA found no significant biological resources on FTIR-38 Area 1, a quantitative risk characterization was not performed for this source area (Shelton, 1999). This area was likewise excluded from evaluation in the Phase II Ecological Validation Study and only FTIR-38 Area 2, FTIR-40 Area 1, and FTIR-40 Area 2 are considered herein.

Using the same quantitative methodology as the Phase I ERA, this Phase II Ecological Validation Study consisted of recalculating exposure doses and hazard quotients for the Mojave ground squirrel using more reasonable exposure assumptions than those found in the Phase I ERA. It is expected that, following this Phase II Ecological Validation Study, potential ecological risks associated with site-related chemicals present in surface soils (0 - 5 foot bgs) will be more precisely predicted and consequently risk management decisions will be based on more certain information.

7.1.1 Objectives and Scope

The Phase I ERA and Phase II Ecological Validation Study were conducted according to the ecological risk assessment methodologies outlined in the approved Workplan (Parsons ES, 1995). Information on ecological habitats, representative receptors, site conceptual models and food webs were provided in the Phase I ERA and are incorporated in this document by reference (Montgomery Watson, 1998).

As in the Phase I assessment, chemicals in subsurface soils (>5 feet bgs) will not be evaluated in this assessment because plants and burrowing animals are not expected to be exposed to soils at this depth. However, other exposure assumptions have been refined for the Phase II Ecological Validation Study:

- Only chemicals that contributed to hazard indices greater than or equal to one for the Mojave ground squirrel in the Phase I ERA are addressed.
- Rather than a maximum concentration, the soil exposure point concentration (EPC) is assumed to be the 95 percent UCL on the site average.
- Rather than literature-based modeled plant concentrations, the plant EPC is the measured site-specific plant 95 percent UCL.
- Identification of ambient or BUTLs have been established. Site-specific reference data for soils and plants were statistically evaluated to determine whether or not the observed concentrations are statistically above BUTLs.

In addition, rather than considering only one set of toxicity reference values (TRVs) compiled by the Army, for comparative purposes this Phase II Ecological Validation Study also calculated hazard quotients using TRVs compiled by the USEPA Region 9 Biological Toxicological Advisory Group (BTAG).

This Phase II Ecological Validation Study was conducted in accordance with the following guidance documents and reference materials prepared by Cal-EPA and USEPA:

- Risk Assessment Guidance for Superfund, Volume II: Environmental Evaluation Manual, Interim Final. USEPA, EPA/540/1-89/001, 1989b.
- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference. USEPA, Environmental Research Laboratory, EPA/600/3-89/013, 1989c.
- Framework for Ecological Risk Assessment. USEPA, EPA/630/R-92/001, 1992c.
- Wildlife Exposure Factors Handbook, Volumes I and II. USEPA, EPA/600/R-93/187a, 1993.
- Role of the Ecological Risk Assessment in the Baseline Risk Assessment. USEPA, OSWER Directive Number 9285.7-17, 1994b.
- Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities. Cal-EPA, July 1996.
- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final. USEPA, June 1998a.
- Guidelines for Ecological Risk Assessment- Final. USEPA, EPA/630/R-95/002F, 1998b.

Additional references used in preparation of this document are cited as they appear.

7.1.2 Organization of the Ecological Risk Assessment

This Phase II Ecological Validation Study for NTC Fort Irwin is organized as follows:

Section 7.1 - Introduction. This section presents a brief introduction, and identifies the objectives and scope of the Phase II Ecological Validation Study conducted for Sites FTIR-38 Area 1, FTIR-40 Area 1, and FTIR-40 Area 2.

Section 7.2 - Phase II Exposure Assessment. This section describes the methods used in the Phase II exposure assessment, including the calculations and assumptions used in ecological exposure modeling.

Section 7.3 – Ecological Toxicity Assessment. This section describes the toxicity criteria selected for use in quantifying risks for the Mojave ground squirrel.

Section 7.4 – Hazard Quotient Calculations. This section presents the methods and results of revised Mojave ground squirrel hazard quotient calculations.

Section 7.5- Statistical Comparisons Between Source Areas and Reference Locations. This section describes the results of statistical comparison of soil and plant data between source areas and reference locations. Included in this section is a description of the statistical methods used to compare data from source areas and reference locations.

Section 7.6- Phase II Risk Characterization. This section synthesizes the hazard quotients calculated in Section 7.4 and the statistical comparisons performed in Section 7.5.

Section 7.7 - Uncertainty Analysis. This section presents a discussion of the potential uncertainties involved in the Phase II Ecological Validation Study and risk characterization.

7.2 PHASE II EXPOSURE ASSESSMENT

The purpose of the exposure assessment phase of an ERA is to describe and quantify (when appropriate) the potential co-occurrence of receptors and chemicals of potential ecological concern (COPECs). The development of an ecological CSM serves to identify all potentially exposed receptors and potentially complete exposure pathways. Representative indicator receptors are selected for purposes of modeling exposures and evaluating potential impacts of COPECs on ecological receptors and habitats. Potential exposures are quantified by estimating COPEC exposure point concentrations in abiotic and biotic media, and subsequent uptake by indicator receptors. The results of the exposure assessment will be considered in relation to the results of the toxicity assessment to characterize ecological risk.

7.2.1 Ecological Conceptual Site Model

Ecological CSMs were presented previously in the Phase I ERA (Montgomery Watson, 1998). They were prepared in a manner consistent with Cal-EPA's *Guidance for Ecological Risk Assessment* (Cal-EPA, 1996) and USEPA's *Framework for Ecological Risk Assessment* (USEPA, 1992c). The ecological receptors occurring or potentially present at NTC Fort Irwin are those associated with creosote scrub and saltbush scrub communities; these habitats formed the basis for the CSM of the Phase II Ecological Validation Study (Figure 7-1).

7.2.2 The Mojave Ground Squirrel: A Representative Receptor

As described in the Phase I ERA, numerous plant and wildlife species are present, or potentially occurring, in the vicinity of NTC Fort Irwin (Montgomery Watson, 1998). Based on the results of the Phase I ERA and the biological habitat assessment performed by DTSC and CDFG, the Mojave ground squirrel was selected for further evaluation in the Phase II ecological validation study. The Mojave ground squirrel was associated with HI values in excess of one in the predictive Phase I ERA.

A Mojave ground squirrel inhabits the upper 3.5 feet of soil (Thelander et al, 1994). A simplified food chain for the Mojave ground squirrel based on additional life history information is shown in Figure 7-2. Plant tissue data was collected to refine the Phase II exposure assessment for the Mojave ground squirrel as described in Section 3.2. The golden eagle, an upper trophic level receptor was not evaluated in the Phase II ecological validation study because HI values for this receptor were below one in the the predictive Phase I ERA (Montgomery Watson, 1998).

7.2.3 Assessment and Measurement Endpoints

As defined in USEPA's *Framework for Ecological Risk Assessment* (USEPA, 1992c), an assessment endpoint is an explicit expression of the environmental value that is to be protected (for example, a decline in a specific species population). A measurement endpoint is defined as a quantitative expression of an observed or measured effect of the hazard; that is, a measurable response to a stressor that is related to the ecological characteristic chosen as the assessment endpoint (USEPA, 1992c).

The objectives of this Phase II Ecological Validation Study are reflected in the assessment endpoint that was selected: namely to protect the growth and survival of organisms represented by the Mojave ground squirrel. A way to determine whether or not assessment endpoints and objectives have been met, the measurement endpoints for this Phase II Ecological Validation Study are:

- Calculation of receptor-specific HQs and HIs for the Mojave ground squirrel. An HI is the sum of the HQs for all site-related chemicals. HQs are calculated by estimating the exposure dose received by the receptor and dividing it by a reference dose that is either anticipated not to cause adverse effects or represents the lowest adverse effect level. The HI approach is applied in estimating the risk to the Mojave ground squirrel in this Phase II Ecological Validation Study.
- Statistical evaluation of site soil data to reference data to determine whether or not calculated risks represent site-related contamination or ambient conditions.

Adequate toxicity information for mammals currently exists for most COPECs evaluated in this Phase II Ecological Validation Study. Therefore, potential ecological hazards for the Mojave ground squirrel were directly evaluated.

7.2.4 Ecological Pathway and Exposure Route Analysis

Uptake through food chain transfer of chemicals in soil was identified as a complete exposure route for the Mojave ground squirrel. Direct exposures of the Mojave ground squirrel to soil through incidental ingestion and dermal contact are also potentially complete exposure pathways. Other exposure routes (e.g., inhalation of particulates) may be potentially complete but were judged unlikely to result in significant exposures. In addition, methods for the evalution of inhalation risks for ecological receptors are not adequately developed. The ingestion route typically dominates ecological exposures (Maughan, 1993). Migration of COPECs to surface water and subsequent ingestion by the Mojave ground squirrel were also deemed to be insignificant. Surface water is nonexistent or seasonal, at best, in the vicinities of the subject sites and desert species are adapted to acquiring their water needs from dietary items (e.g , plants for the Mojave ground squirrel).

7.2.5 Exposure Point Concentrations of Soils and Plants

The EPCs used in exposure calculations are presented in Tables 7-1 though 7-6 The methods used in the derivation of EPCs for the ERA were the same as those used for the HHRA, and were described previously (Section 5 3.5 1). Briefly, for each COPEC in surface soil (0 to 5 foot bgs) or plants, the lower value of the 95 percent UCL of the mean or maximum concentration was assumed to be the EPC.

7.2.6 Exposure Parameters

Exposure parameters for the Mojave ground squirrel were required to estimate the exposure dose. Exposure parameters were obtained from USEPA's *Wildlife Exposure Factors Handbook* (USEPA, 1993), the *Field Guide to North American Mammals* (Whitaker, 1996), and *California's Wildlife* (Zeiner et al., 1990). The exposure parameters required for the quantitative dose estimate include the receptor's:

- Body weight
- Ingestion rate of biotic and abiotic media
- Dermal contact rates with abiotic media (e.g., soil)
- Site utilization factor (the area of contamination in relation to the receptor's home range)
- Exposure duration (time in a year that a receptor is exposed to site COPECs)
- Skin surface area
- Chemical-specific dermal absorption factors
- Soil adherence factors.

The assumed exposure parameters are listed in Table 7-7 and detailed in the following subsections.

7.2.6.1 Body Weight. Body weights (BWs) for the Mojave ground squirrel were obtained from the National Audubon Society's *Field Guide to North American Mammals* (Whitaker, 1996). The average body weights reported for both males and females were used for each indicator receptor.

7.2.6.2 Biotic Ingestion Rates. The food ingestion rate (IR) for the Mojave ground squirrel was calculated using allometric equations provided in USEPA's *Wildlife Exposure Factors Handbook* (USEPA, 1993) that are based on established relationships between body size and metabolic requirements. Food ingestion rate was calculated based on Equation 3-9 for herbivores (USEPA, 1993).

7.2.6.3 Abiotic Ingestion Rates. The abiotic ingestion rate (for incidental soil ingestion) was obtained from USEPA (1993). The abiotic ingestion rate for the Mojave ground squirrel was based on a reported soil ingestion rate for the meadow vole.

7.2.6.4 Site Utilization Factor. The site utilization factor (SUF) describes the area of contamination that a receptor potentially contacts relative to its home range. Home range is the area of habitat required by an ecological receptor to meet its dietary needs. Home ranges vary between species depending upon differences in dietary requirements, and within a species depending upon the relative abundance of food items in a particular area in which the receptor feeds. The home range of the Mojave ground squirrel was obtained from the *Field Guide to North American Mammals* (Whitaker, 1996). Comparison of a receptor's home range to the areal extent of contamination of a site is used to determine the relative amount of potentially contaminated diet the receptor injests. The SUF is calculated as the ratio of the area of contamination to a receptor's home range. When the receptor's home range is greater than the area of contamination, the SUF is less than one. When a receptor's home range is less than or equal to the area of contamination the SUF defaults to one. Site-specific exposure areas and SUFs are presented in Table 7-7.

7.2.6.5 Exposure Duration. The exposure duration (ED) refers to the fraction of the year that a receptor is likely to spend utilizing a site. This is frequently a function of migration and/or hibernation potential. The Mojave ground squirrel estivates in the upper 3.5 feet of soil from approximately August to March. Therefore, the exposure duration for the Mojave ground squirrel was assumed to be 0.5 (unitless; 6 months out of 12 months).

7.2.6.6 Skin Surface Area. The skin surface area (SSA) is an exposure parameter used to estimate dermal exposure of indicator receptors to soil COPECs. This parameter was calculated based on methods outlined in the *Wildlife Exposure Factors Handbook* (USEPA, 1993). Equation 3-22 (USEPA, 1993) was used for the Mojave ground squirrel. The calculation using this allometric equation yields an estimate of total skin surface area beneath the fur or feathers. For purposes of this assessment, the dermal portion of the Mojave ground squirrel's body that may receive potentially significant exposures to soil was assumed to be the feet (4 percent of total body surface area). It was assumed that fur would tend to protect other body surfaces from dermal exposure.

7.2.6.7 Chemical-Specific Dermal Absorption Fraction. The chemical-specific dermal absorption fraction (ABS) is used in the estimate of dermal exposure to contaminants in soil or sediment. The ABS represents the ratio of the absorbed dose to the applied dose of a chemical (USEPA, 1992c). An average dermal absorption fraction of 0.1 (i.e., 10 percent) for organic chemicals, and 0.01 (i.e., 1 percent) for inorganic chemicals, has been published by USEPA (1992c) for use in HHRA. These dermal absorption fractions were used in this ERA for estimating doses derived from dermal exposures.

7.2.6.8 Soil Adherence Factor. The soil-to-skin adherence factor (AF) is also used in the estimation of dermal exposure to contaminants in soil. This parameter depends in part on chemical properties and in part on soil characteristics, such as total organic carbon and particle size. A soil-to-skin AF of 0.2 mg/cm^2-day (USEPA, 1992c) was assumed for the Mojave ground squirrel.

7.2.7 Exposure Dose Calculation

The final phase of the exposure assessment consolidates the exposure pathways and exposure routes, exposure point concentrations, and exposure parameters into an equation that provides an exposure dose estimate in units of milligrams of COPEC per kilogram body weight per day. Ingestion dose estimates are calculated using the following general equation derived from USEPA's *Wildlife Exposure Factors Handbook* (USEPA, 1993):

$$Dose_{Ingestion} = \frac{[(IR_{Biotic} \; x \; EPC_{Biotic}) + (IR_{Abiotic} \; x \; EPC_{Abiotic})] \; x \; ED \; x \; SUF}{BW}$$

where:

$Dose_{Ingestion}$	=	Estimated exposure dose from ingestion of food and ingestion of abiotic media (mg/kg-d)
IR_{Biotic}	=	Food ingestion rate (kg/day)
$IR_{Abiotic}$	=	Abiotic media ingestion rate (kg/day)
EPC_{Biotic}	=	Concentration of COPEC in food item (mg/kg)
$EPC_{Abiotic}$	=	Concentration of COPEC in abiotic media (mg/kg)
ED	=	Exposure Duration (unitless)
SUF	=	Site Utilization Factor (unitless)
BW	=	Body weight (kg)

For lead, a bioavailablity factor of 0.2 (unitless) was also applied to the numerator to account for the difference between the absorption of inorganic forms of lead in soil versus the organic form (lead acetate) used in the toxicity study upon which the toxicity value is based (Maddaloni et. al, 1998). Dermal exposure estimates were calculated for indicator receptors using the following general equation:

$$Dose_{Dermal} = \frac{EPC_{Abiotic} \; x \; SSA \; x \; AF \; x \; ABS \; x \; ED \; x \; SUF \; x \; UC}{BW}$$

where:

$Dose_{Dermal}$	=	Estimated dose from dermal contact with soil (mg/kg-day)
$EPC_{Abiotic}$	=	Exposure point concentration in soil (mg/kg)
SSA	=	Skin Surface Area (cm^2)

AF	=	Soil adherence factor (mg/cm^2-day)
ABS	=	Chemical-specific dermal absorption fraction (unitless)
ED	=	Exposure Duration (unitless)
SUF	=	Site Utilization Factor (unitless)
UC	=	Unit Conversion, 10^{-6} (kg/mg)
BW	=	Body Weight (kg)

For each of the investigation sites, the total chemical dose to the Mojave ground squirrel is the sum of the ingested dose and the dermal dose. In this report, calculated doses are presented along with the hazard quotients developed in Section 7.4.

7.3 ECOLOGICAL TOXICITY ASSESSMENT

In this Phase II Ecological Validation Study, two sets of TRVs are used for risk analysis:

- Army TRVs: These TRVs are presented in Table 7-8. With the exception of lead, the Army adopted ecological toxicity benchmarks that are published in *Toxicological Benchmarks for Wildlife* (Sample et al., 1996) as their TRVs, while the lead TRV was selected through an independent analysis of the literature by the US Army Environmental Center.
- BTAG TRVs: These TRVs are presented in Table 7-9. At the request of DTSC, TRVs compiled by the USEPA Region 9 BTAG were also adapted for use in this assessment (EFA-West, 1998).

Whenever possible, toxicity benchmarks from Sample et. al. (1996) and EFA-West (1998) were based on experimentally derived NOAELs or lowest-observed-adverse-effects levels (LOAELs). In cases where a NOAEL was not available for a particular COPEC, uncertainty factors were applied to reduce the TRV by an order-of-magnitude or more. In both documents, initial emphasis was placed on studies in which reproductive and developmental endpoints were considered. However, in cases where limited studies were available, or non-reproductive or non-developmental effects occurred at doses lower than those causing reproductive or developmental effects, TRVs were based on non-reproductive and non-developmental endpoints.

Sample et al. (1996) and EFA-West (1998) both report benchmarks for a test species. Since benchmarks were not specifically available for the Mojave ground squirrel, toxicity benchmarks provided for the test species were allometrically converted to a TRV using the following equation described in Sample et al. (1996):

$$Dose_I = Dose_T \, x \, (BW_T / BW_I)^{0.25}$$

where:

$Dose_I$	=	Toxicity reference value for indicator receptor (mg/kg-d)
$Dose_T$	=	Benchmark NOAEL dose for test species (mg/kg-d)
BW_T	=	Body weight for test species (kg)
BW_I	=	Body weight for indicator species (kg)

The Army and BTAG TRVs for the Mojave ground squirrel are presented in Tables 7-8 and 7-9, respectively.

7.4 HAZARD QUOTIENT CALCULATIONS

The input parameters and equations used for calculating Mojave ground squirrel exposure doses are provided in Section 7.2. The TRVs developed to interpret modeled doses are presented in Section 7.3. In the following section, the methods and results of ecological hazard calculations are provided.

7.4.1 Methods

To assist with risk characterization, HQs were calculated for each site-related COPEC. The HQ is defined as follows:

$$HQ = \frac{Dose}{TRV}$$

where:

HQ	=	Hazard quotient (unitless)
Dose	=	Modeled exposure dose for the Mojave ground squirrel (mg/kg-d)
TRV	=	Toxicity reference value for the Mojave ground squirrel (mg/kg-d)

Additionally, to estimate the cumulative effects of COPECs, a HI was calculated. The HI was determined by adding the HQs obtained from food chain modeling for all COPECs identified at a site. HQ or HI values exceeding 1 are generally considered to be indicative of potential adverse biological or ecological effects for representative receptors. These values do not necessarily indicate that a biological or ecological effect will occur, but only that a lower threshold has been exceeded (Menzie, et al., 1992). In general, the evaluation of the significance of the HQ and HI values was conducted in a manner consistent with Menzie, et al. (1992), as follows:

- HQ or HI less than 1: no adverse effects on representative receptors is anticipated
- HQ or HI between 1 and 10: there is a limited potential for adverse effects on representative receptors
- HQ or HI between 10 and 100: there is potential for adverse effects on representative receptors
- HQ or HI exceeds 100: there is significant potential for adverse effects on representative receptors

Note that the above are only guidelines. Site-specific factors such as spatial distribution and frequency of detection of COPECs, uncertainty of assumptions used in exposure determination, and endpoint of study used to determine the toxicity benchmarks need to be considered when reviewing specific HQs and HIs.

7.4.2 Results of Calculations

Ecological hazard estimates for the Mojave ground squirrel are presented in Tables 7-10 through 7-16. Hazard quotients are calculated using both Army and BTAG TRVs. To provide perspective, hazard estimates are calculated for both source areas and corresponding reference areas.

7.5 STATISTICAL COMPARISONS BETWEEN SOURCE AREAS AND REFERENCE LOCATIONS

This section describes the results of statistical comparison of soil and plant data between source areas and reference locations. Included in this section is a description of the statistical methods used to compare data from source areas and reference locations.

7.5.1 Statistical Methods

Two types of statistical comparisons were performed to determine whether soil and plant data collected from the sites are significantly elevated above background: (1) distribution tests and (2) extreme value tests. Distribution tests are statistical tests to determine whether the central tendencies of two groups of data are similar, and are used to determine if, on average, site concentrations differ significantly from background concentrations. Extreme value tests are statistical tests used to compare individual results from an affected site to some function of the background data (e.g., upper tolerance limit), and are commonly used to identify 'hot spots'. In accordance with USEPA's Region 8 Superfund Technical Guidance document titled, *Evaluating and Identifying Contaminants of Concern for Human Health* (USEPA, 1994c), distribution tests were chosen to support the risk assessment where data were adequate to perform such a test.

The individual statistical method used to compare site and reference data was based on the distribution of the data and the percent non-detects in the site and reference data populations. When there were at least five samples in both the site and reference populations, the distribution of each of the data sets was tested using the Coefficient-of-Variation Test. The Coefficient-of-Variation Test is an effective method of determining whether or not the data has been drawn from an underlying normal distribution. This test method is described in detail in *Statistical Methods for Environmental Pollution Monitoring* (Gilbert, 1987). The Coefficient-of-Variation is calculated as the ratio of the standard deviation and the mean for a given data set, as follows:

$$CV = \frac{S}{X}$$

Where:

CV	=	Coefficient-of-Variation
S	=	Standard deviation of the site or reference population
X	=	Arithmetic mean of the site or reference population

If the CV exceeds 1.0, there is evidence that the data are not taken from an underlying normal distribution and population normality will not be assumed. The appropriate distribution (i.e., either normal or lognormal) must be identified to determine whether statistical comparisons between site and reference populations are conducted using parametric or non-parametric methods.

If the distribution of site and reference location populations are normal and these sample populations contained greater than 50 percent detected values above the reporting limit, the Student t-Test was selected as the appropriate statistical test. The Student t-Test is a distribution test involving the t test statistic and is used to determine whether statistical differences exist between two sample population means. To use the t-statistic, both sampled populations must be normally distributed and with approximately equal population variances, and the random samples must be selected independently of one another. The calculation of the t-statistic is as follows:

$$t = \frac{(Xs - Xr) - Do}{[s_p^2(1/n_s + 1/n_r)]^{1/2}}$$

Where:

t	=	Test statistic
Xs	=	Arithmetic mean of site population
Xr	=	Arithmetic mean of reference population
Do	=	Expected difference between means (Do = 0)
s_p^2	=	Pooled variance
n_s	=	Number of samples in the site population
n_r	=	Number of samples in the reference population

The pooled variance (s_p^2) is simply a weighted average of the two sample variances, and is calculated as follows:

$$s_p^2 = \frac{\Sigma(Xsi - Xs)2 + \Sigma(Xri - Xr)2}{(n_s - 1) + (n_r - 1)}$$

Where:

Xsi	=	An individual measurement from the site population
Xri	=	An individual measurement from the reference population

The t-statistic calculated for each comparison was compared to the rejection region for a confidence level of 95 percent. Thus, for $\alpha = 0.05$, the one-tailed rejection region for the test was $t > t_{0.95}$, where the value for $t_{0.95}$ was derived from the t-distribution (tabulated in USEPA's *Statistical Analysis of Ground-Water Monitoring Data at Resource Conservation and Recovery Act [RCRA] Facilities, Interim Final Guidance* [USEPA, 1989b]). For each comparison for which the t-statistic exceeded $t_{0.95}$, significant differences were assumed to exist between the site and reference population means. If the mean of the site sample population was greater than the mean of the reference sample population, then the null hypothesis (Ho: Xs = Xr) was rejected and the site sample population was assumed to represent contamination. If the t-statistic was less than $t_{0.95}$, then the null hypothesis was accepted and the site and reference means were assumed to be from the same population (i.e., no contamination).

The Student's t-Test may be performed on sample populations having log-normal distributions. If the test of normality suggested that the distribution of *both* site and reference populations were log-normal, and greater than 50 percent of the site and reference sample populations contained detections above the reporting limit, then the Student's t-Test was performed on the logarithms of the original concentrations.

If the distributions of the site and reference sample populations were neither both normal nor both log-normal, the Mann-Whitney Test was selected as the appropriate statistical test because this method does not depend upon the underlying distribution of the data. The Mann-Whitney

Test was also used in cases where less than 50 percent, but greater than 10 percent, of the site or reference sample populations contained detections above the reporting limit.

The Mann-Whitney Test was performed by first ranking all the site and reference sample data as though they were drawn from the same population. A rank of 1 was assigned to the smallest datum in the two data sets, a rank of two was assigned to the next largest datum, etc. In the case of ties (i.e., several data had the same value), the data were assigned the mid-rank, that is, the average of the ranks that would otherwise have been assigned to those data. In the case of non-detect values (ND), one-half the reporting limit was assumed and the corresponding rank was assigned. If ND data represented the same values (i.e., had the same reporting limit), they were assumed to be tied and the mid-rank was assigned. The test statistic, U, for the Mann-Whitney Test is based on the totals of the ranks for each of the two populations, or the "rank sums". The calculation of the U-statistic is as follows:

$$U = Ws - \frac{ns(ns+1)}{2}$$

Where:

U	=	Test statistic
Ws	=	Sum of the ranks of the values for the site population
ns	=	Number of samples in the site population

For larger sample populations ($n \geq 10$), this statistic was then used to calculate a z test statistic. The z-statistic was used to test the null hypothesis that the populations associated with the site and reference data were equivalent. The calculation of the z-statistic is as follows:

$$z = \frac{U - \frac{(ns \times nr)}{2}}{\left[\frac{ns \times nr(ns + nr + 1)}{12}\right]^{1/2}}$$

Where:

z	=	Test statistic
U	=	U-statistic
ns	=	Number of samples in the site population
nr	=	Number of samples in the reference population

The z-statistic calculated for each comparison was compared to the rejection region for a confidence level of 95 percent. Thus, for $\alpha = 0.05$, the one-tailed rejection region for the test was $z > z_{0.95}$, where the value for $z_{0.95}$ was derived from the z-distribution (tabulated in Table A1 of *Statistical Methods for Environmental Pollution Monitoring* (Gilbert, 1987). For each comparison for which the z-statistic exceeded $z_{0.95}$, the null hypothesis was rejected and the site sample population was assumed to represent contamination. If the z-statistic was less than $z_{0.95}$, then the null hypothesis was accepted and the site and reference populations were assumed to be equivalent (i.e., no contamination).

When the percentage of detections above the reporting limit was less than 10 percent in either the site or reference sample populations, the Poisson Prediction Limit Test was used to evaluate whether there was a difference in the populations. This test is generally used when the probability of a chemical being detected is low, but remains constant from sample to sample. An upper prediction limit can be calculated from this test as follows:

$$Ts^* = cTr + ct^2 + ct\sqrt{T_r(1 + 1/c) + t^2/4}$$

Where:

Ts*	=	Upper limit of the sum of the concentrations of the site population
Tr	=	Sum of the concentrations of the reference population
nr	=	Number of samples in the reference population
ns	=	Number of samples in the site population
c	=	ns/nr
t	=	Value of the t distribution at the $1 - \alpha$ percentile ($\alpha = 0.05$) with nr – 1 degrees of freedom

The sum of the concentrations of the site population was compared to Ts*. In the case of ND, one-half the reporting limit was assumed in calculating the sum of the concentrations of the site population or reference population (Tr). If the sum of the site concentrations was greater than Ts*, the null hypothesis was rejected (i.e., there is greater than 95 percent confidence that the site concentrations represent contamination). If the sum of the site concentrations was less than Ts*, the null hypothesis was accepted and the site and reference data were assumed to be from the same population (i.e., no contamination).

7.5.2 Results of Statistical Comparisons

Complete results of all statistical comparisons are provided in Appendix N. Tables 7-16 and 7-17 present results of statistical comparisons for Phase II COPEC with hazard quotients greater than or equal to one. These COPEC were identified by using either the Army TRV or BTAG TRV in the hazard quotient calculation. Although a few metals were found in site soils above ambient concentrations, it is interesting to note that only copper appears to be in plants at a higher concentration than reference plants at one site, Site FTIR-40 Area 1.1.

7.6 RISK CHARACTERIZATION

The Phase I ERA concluded that chemical concentrations in soils associated with the subject sites may pose a risk to the Mojave ground squirrel. Therefore, the overall goals of the Phase II Ecological Validation Study were to refine site-specific exposure assessments and to re-evaluate whether or not COPEC concentrations identified in NTC Fort Irwin soils pose a potential risk to the Mojave ground squirrel.

7.6.1 Methods

As described in Section 7.2.3, the measurement endpoints evaluated in this ERA include:

- Comparison of refined modeled exposure doses with toxicity reference values for the Mojave ground squirrel and

- Comparison of site plant and soil data to reference data.

The comparison of exposure doses with toxicity reference values yields chemical specific HQs. HQ or HI values exceeding 1 are generally considered to be indicative of potential biological or ecological effects on representative receptors. These values do not necessarily indicate that a biological or ecological effect will occur, but only that a lower threshold has been exceeded; hazard quotients greater than one and less than 10 are thought to have a limited potential for effects (Menzie, et al., 1992; Section 7.4.1, above). The comparison between site and reference data yields a site-specific understanding of chemical risks posed by ambient chemical conditions, to which the organism's population has adapted.

7.6.2 Results

In Table 7-18, the results of Phase II Ecological Validation Study HQs and statistical comparisons are presented. Chemicals were identified in the Phase I ERA as a chemical of ecological concern (COEC) for evaluation in the FS, if the chemical:

- Exhibited a hazard quotient greater than one, based on either the Army TRV or the BTAG TRV and
- Was present in concentrations greater than reference concentrations

It is recommended that COECs be considered for risk management. A list of chemicals, by site, recommended for potential risk management action is provided in Table 7-19.

7.6.2.1 Site FTIR-38 Area 2. The Phase I ERA identified potential risks to the Mojave ground squirrel from eight metals: aluminum, antimony, arsenic, barium, cobalt, copper, lead and zinc. Following the Phase II Ecological Validation Study, hazard estimates in excess of 1.0 were confirmed for three metals. Aluminum and antimony had HQs greater than 1.0 using the Army TRVs (Table 7-10), and lead had a hazard quotient greater than 1.0 using the BTAG TRVs (Table 7-11). Ecological HQ estimates for aluminum and antimony were 36 and 2 for Site FTIR-38 Area 2; and 31 and 2 for Reference Area 1. When site soil data are compared to local reference soil data, it was found that site antimony concentrations were indicative of ambient conditions (Table 7-16). Only aluminum was associated with an HQ greater than 1.0 based on Army TRVs, *and* site concentrations greater than Reference Area 1 concentrations. Based on BTAG TRV-Low values, an ecological HI of 795 was estimated, which was primarily attributable to lead (HQ = 794). This was in comparison to an HI of 7 for Reference Area 1 based on BTAG TRV-Low values, which was primarily attributable to lead (HQ = 6). Lead concentrations at Site FTIR-38 Area 2 were significantly greater than Reference Area 1 concentrations. Thus, following this Phase II Validation Ecological Study, aluminum and lead were retained as COECs for consideration in the FS.

7.6.2.2 Site FTIR-40 Area 1.1. The Phase I ERA identified potential risks to the Mojave ground squirrel from fourteen metals: aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, nickel, selenium, silver and zinc. Following the Phase II Ecological Validation Study, hazard estimates in excess of 1.0 were confirmed for six metals. Aluminum, antimony, copper and lead had HQs greater than 1.0 using the Army TRVs (Table 7-12); and cadmium, copper, lead and zinc had hazard quotients greater than 1.0 using the BTAG TRVs (Table 7-13). Ecological HQ estimates for aluminum and antimony were 28 and 3 for Site FTIR-40 Area 1.1, and 20 and 2 for Reference Area 2 based on Army TRVs. When site soil and plant concentrations were compared to local reference concentrations, it was found that site aluminum and antimony concentrations are indicative of ambient conditions (Table 7-16). Ecological HQs for copper and lead were 1 and 9 for Site FTIR-40 Area 1.1, and 0.01 and 0.007 for Reference Area 2 based on Army TRVs. However, only copper was associated with site soil and plant concentrations greater than Reference Area 2 concentrations. Based on BTAG TRV-Low values, an ecological HI of 8074 was estimated, which was primarily attributable to lead (HQ = 8055). This was in comparison to an HI of 7 for Reference Area 2 based on BTAG TRV-Low values, which was primarily attributable to lead (HQ = 6). Although lead concentrations at Site FTIR-40 Area 1.1 were not significantly greater than Reference Area 2 concentrations, this is believed to be due to the larger variance in the data. Consequently, lead was retained as a COEC for Site FTIR-40 Area 1.1. Ecological HQs for cadmium, copper and lead were 3, 12 and 3, respectively, for Site FTIR-40 Area 1.1 based on BTAG-Low TRVs and 0.2, 0.1 and 0.06 for Reference Area 2. In addition, concentrations of cadmium, copper and zinc in Site FTIR-40 Area

1.1 soils were significantly greater than Reference Area 2 concentrations (Table 7-16). Thus, following this Phase II Ecological Validation Study, cadmium, copper, lead and zinc were retained as COECs for consideration in the FS.

7.6.2.3 Site FTIR-40 Area 2. The Phase I ERA identified potential risks to the Mojave ground squirrel from four metals: arsenic, cadmium, lead and zinc. Following the Phase II Ecological Validation Study, however, an ecological HI of less than 1.0 was calculated based on the Army TRVs. An HQ of 22 was estimated for Site FTIR-40 Area 2 using BTAG-Low TRVs, which was entirely attributable to lead. This was in comparison to an HI of 7 for Reference Area 2 (lead HQ = 6). However, when site soil data were compared to local reference soil data, it was found that site lead concentrations were indicative of ambient conditions (Table 7-16). Thus, following this Phase II Ecological Validation Study, no chemicals at Site FTIR-40 Area 2 required consideration in the FS based on ecological considerations.

7.7 UNCERTAINTY ANALYSIS

The presence of uncertainty is inherent in the risk assessment process. Generally, uncertainties in the risk assessment typically result from limitations in the available methods, information, and data used in the following:

- Characterization of contaminant sources
- Identification of site COPECs
- Evaluation of potential exposure scenarios and pathways
- Toxicity assessment
- Risk characterization

The uncertainties associated with each of these steps as they relate to the Phase I ERA for Sites FTIR-38 - Area 2, FTIR-40 - Area 1, and FTIR-40 - Area 2 are described below.

7.7.1 Characterization of Contaminant Sources

There is a degree of uncertainty in the characterization of contaminant sources, since it is not possible to sample an entire site. The site investigations were based on site histories, known releases, or the results of previous investigations (i.e., soil gas measurements or preliminary monitoring). The nature of these site investigations focused on known or suspected sources of contamination. While it is believed that sufficient samples were collected to characterize the nature and extent of contamination at the sites, it is possible that areas not sampled may have also contained contaminants. However, sample locations were generally chosen such that they represented the area with the greatest potential to detect contaminants, if present.

Subsurface soil samples were not collected and analyzed for Sites FTIR-38 Area 2, FTIR-40 Area 1, and FTIR-40 Area 2. This introduces some uncertainty in the characterization of risks associated with soils in these source areas. However, the sites within these areas have been used extensively for firing range activities including the surface detonation of munitions. Therefore, subsurface sources of contamination are not anticipated to be present. Nevertheless, this represents a source of uncertainty.

7.7.2 Identification of Site Chemicals of Potential Ecological Concern

The process used in the selection of site COPECs may also introduce a degree of uncertainty in the ERA. However, protective assumptions were used in the selection of site COPECs. Chemicals selected for quantitative evaluation in the Phase I ERA included all organic chemicals identified in soils and inorganic chemicals present at concentrations greater than background (Montgomery Watson, 1998). Chemicals selected for evaluation in the Phase II Ecological Validation Study had all contributed to a HI greater than 1.0 in the Phase I ERA.

The inorganics calcium, iron, magnesium, potassium, and sodium were eliminated from consideration as COPECs for the Mojave ground squirrel, based on essential nutrient status. These inorganic chemicals have relatively low toxicities and are generally of low concern for potential impacts on non-plant terrestrial receptors. Zinc is also an essential nutrient that was eliminated as a potential COPC in the HHRA based on essential nutrient status. However, zinc is capable of producing adverse ecological impacts in some aquatic and terrestrial receptors at fairly low environmental concentrations. Therefore, zinc was not eliminated as a COPEC for this ERA.

7.7.3 Exposure Assessment

Uncertainties associated with the exposure assessment include: (1) the selection of indicator receptors; (2) the exposure assumptions and parameters used; and (3) the exposure dose estimates. Representative indicator receptors were selected for quantitative evaluation in the Phase I ERA based on the criteria identified in Section 6.4.2 of that document (Montgomery Watson, 1998). Many exposure parameters (e.g., soil ingestion rates, dermal surface areas, and absorption fractions) were not available for the Mojave ground squirrel, and best estimates based on similar species or allometric equations were used. This introduces a level of uncertainty into the exposure estimate. However, appropriate exposure values and estimation methods were taken from the *Wildlife Exposure Factors Handbook* (USEPA, 1993), when available.

Uncertainties in the exposure point concentrations also result in uncertainty in the exposure dose estimate. Exposure point concentrations evaluated in this Phase II ERA were based on the 95 percent UCL of chemicals measured in soils from 0 to 5 feet bgs. Use of the 95 percent UCL exposure point concentration results in a protective and reasonable estimate of exposure to soil and plants, given that receptors tend to forage in different locations of a site and would not be exposed to the highest concentrations 100 percent of the time. However, exposure to the highest concentrations is not directly considered, nor is avoidance behavior of impacted areas. Since the Mojave ground squirrel inhabits soils from 0 to 3.5 feet bgs, it is unclear what the affect of including the deeper soils data may have on this assessment.

7.7.4 Toxicity Assessment

The toxicity benchmarks used in the quantitative evaluation of ecological hazards for the indicator receptors were generally derived from the lowest NOAEL or LOAEL data obtained from the literature. Uncertainty factors were applied where appropriate in deriving the benchmarks, and the most protective values from the literature were used. The use of conservative toxicity values in the risk estimate tends to overestimate actual risks.

The species upon which the benchmark criteria are based were different from those present at the site. Because toxicity values are often not available for a species, toxicity benchmarks derived for a surrogate species are selected for quantitative risk evaluation. Toxicity benchmarks derived from toxicology studies in rats and mice were allometrically converted for each indicator receptor, based on established methods (Opresko et al., 1994). It is not known whether the indicator receptors chosen may be more sensitive or less sensitive to the adverse effects of COPECs identified at the sites than the test species upon which the toxicity benchmark is based. However, the benchmarks are thought to be protective because they are based on the lowest toxicity values from all test species reported in the literature.

An additional source of uncertainty results from a lack of toxicity values for some COPECs. Army TRVs were not available for cobalt or silver (Table 7-8), and BTAG TRVs were not available for aluminum, antimony, barium, chromium, or silver (Tables 7-9a and b). Therefore, the potential hazard associated with these COPECs were not included in the respective HIs calculated using the Army TRVs or BTAG TRVs. This issue is probably most significant in the case of aluminum, which was identified as a potential COEC based on use of the Army TRVs but was not evaluated in risk estimates using the BTAG TRVs. Secondly, there is considerable variation in the magnitude of the Army TRV and BTAG TRVs for certain COPECs. For example, the BTAG low TRV for lead is approximately three orders of magnitude lower (i.e., more potent) than the Army TRV for lead. Consequently, the HQ estimates for lead also vary by approximately three orders of magnitude depending upon whether BTAG low TRVs or Army TRVs were used. This fact contributes to considerable uncertainty in the hazard estimates for lead. This issue has been the subject of several meetings between the Army and DTSC. In response to this issue, the United States Army Center for Health Promotion and Preventive Medicine (USACHPPM) has recently submitted a request for review of the BTAG TRV low for lead.

7.7.5 Risk Characterization

The sources of uncertainty previously described are incorporated in the risk estimate. Because the majority of these uncertainties err on the conservative side, the risk estimate is considered to be protective. Nevertheless, there is a degree of uncertainty in the quantitative hazard estimates presented in this ERA, based on the uncertainties previously described.

8.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND REMEDIAL ACTION OBJECTIVES

This section presents the potentially applicable or relevant and appropriate requirements (ARARs) and remedial action objectives (RAOs) for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1. These sites will be evaluated because COCs were identified in the HHRA (Section 6.0) and potential constituents of ecological concern (COECs) were identified in the Phase II Ecological Validation Study (Section 7.0). Other portions of Sites FTIR-38 and FTIR-40 have been eliminated from further consideration because they do not pose a human health or ecological risk for any constituent based on the results of the RI and the analyses conducted in the HHRA and Phase II Ecological Validation Study.

The RI, HHRA, and Phase II Ecological Validation Study presented data to support that surface soils in Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 are potentially impacted with COCs and COECs that need to be addressed in the FS. Other media were either not present (surface water, sediment) or were not impacted (groundwater, subsurface soil, air). Therefore, the remainder of Section 8.0 will identify ARARs and will develop RAOs and site-specific cleanup levels (SSCLs) for surface soils in Sites FTIR-38 Area 2 and FTIR-40 Area 1.1.

8.1 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CRITERIA

The identification of ARARs and "To Be Considered" (TBC) criteria is required for sites performing environmental action in compliance with CERCLA, as amended by the SARA. This section identifies potential ARARs and TBC criteria for remedial alternatives evaluated in the FS.

8.1.1 Definitions of ARARs and TBC Criteria

As stipulated in Section 121(d) of CERCLA as amended by SARA, ARARs are to be attained upon completion of the selected remedial action where COCs remain in place, unless these ARARs are waived by the lead agency. The National Oil and Hazardous Substance Pollution Contingency Plan (NCP) defines "applicable" requirements as:

> *"those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable" (40 Code of Federal Regulations [CFR] 300.5)."*

The NCP further defines "relevant and appropriate" requirements as:

> *"those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (40 CFR 300.5)."*

The three categories of ARARs recognized by the USEPA are chemical-specific, action-specific, and location-specific. Each of these categories is described below.

- Chemical-specific ARARs are specific to the COCs detected at each site and are based on health- or risk-based numeric standards established through exposure scenarios. These values establish acceptable COC concentrations that are protective of human health or the environment.
- Action-specific ARARs are generally technology- or activity-based requirements or limitations established under a federal or state law. These requirements are identified based on the particular activities of a remedy. Thus action-specific requirements do not in themselves determine the remedial alternative; rather, they determine the regulatory framework by which a selected action is to comply, if implemented.

- Location-specific ARARs are restrictions placed upon the implementation of remedial activities based solely on the locale of a particular site. Examples of possible location-specific ARARs include specific provisions of such laws as the National Historic Preservation Act (NHPA) or the Endangered Species Act (ESA).

Non-promulgated regulations, advisories, criteria, guidances, or TBCs issued by federal or state agencies may also be identified to assist in establishing cleanup goals. TBCs are not legally binding and their use is discretionary. TBCs may be useful in implementing ARARs and in determining preliminary remediation objectives in the absence of promulgated standards.

8.1.2 Identification of Potential ARARs and TBCs

This section describes potential ARARs and TBCs for Sites FTIR-38 Area 2 and 40 Area 1.1 that are addressed in this section. Potential ARARs and TBCs are summarized in Tables 8-1 through 8-3 as follows:

- Table 8-1 - Potential Chemical-Specific ARARs and TBCs for COCs, and COECs
- Table 8-2 - Potential Action-Specific ARARs and TBCs
- Table 8-3 - Potential Location-Specific ARARs and TBCs

8.1.2.1 **Potential Chemical-Specific ARARs and TBCs.** There are no ARARs for soils, however, TBCs include:

- USEPA Region 9 PRGs
- USEPA SSLs
- BUTL developed for the site constituents in soil (Section 4.0)
- COCs developed in the HHRA (Section 6.0)
- TRVs developed by the USEPA Region 9 BTAG (Section 7.0)
- TRVs adopted by the Army for use at Fort Irwin (Section 7.0)
- COECs developed in the ERA (Section 6.0)

These TBCs are primarily screening criteria. PRGs and SSLs are generally used to help differentiate impacted media from ambient and are not typically used as cleanup standards; rather, concentrations exceeding these criteria indicate that further study is warranted.

The HHRA (Section 6.0) identified one COC, lead, in surface soils associated with Sites FTIR-38 Area 2 and FTIR-40 Area 1.1. The ERA identified five potential COECs including aluminum, cadmium, copper, lead, and zinc in surface soils associated with Sites FTIR-38 Area 2 and FTIR-40 Area 1.1. Note that the constituents identified in the ERA are referred to here as "potential" COECs because the risks (hence, levels of environmental significance) vary depending upon whether Army or BTAG TRVs are used in the evaluation of risks. A primary objective of this section is to identify those COECs for which a detailed analysis of alternatives should be performed in the remainder of this FS. A summary of the chemical-specific ARARs and TBCs for these COCs and potential COECs is presented in Table 8-1.

8.1.2.2 Potential Action-Specific ARARs and TBCs. Action-specific ARARs are technology- or activity-based requirements or limitations for actions conducted at a site during remediation. The potential action-specific ARARs and TBCs for possible remedial actions at Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 are summarized in Table 8-2.

Potential Federal Action-Specific ARARs and TBCs. The following federal action-specific ARARs and TBCs have been identified for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1:

Clean Air Act, National Primary and Secondary Ambient Air Quality Standards (NAAQS) (40 CFR 50)

Section 109 of the Clean Air Act (CAA) defines NAAQS that are listed in 40 CFR 50. Under certain circumstances, such as generating particulate matter during soil excavation or construction involving earth moving, these standards would be applicable.

RCRA Regulations (40 CFR Parts 261, 262, 264 and 268)

California is authorized to administer the RCRA program, and the state regulations in Title 22 of the California Code of Regulations (CCR) are considered to address the federal requirements. However, the federal RCRA ARARs are summarized as follows for completeness:

40 CFR 261. Part 261 defines the solid wastes that are subject to regulation as listed wastes, and the hazardous waste characteristics that require a solid waste to be classified as a hazardous waste (even if it was not a listed waste). These regulations are applicable to wastes generated during actions such as drilling, excavation and trenching.

40 CFR 262. This part establishes standards for generators of hazardous waste, including classification, packaging, labeling, accumulation time, and transport actions. These standards are applicable to all actions involving hazardous waste generation and management, including wastes generated through actions such as drilling, excavation, and trenching.

40 CFR 264. This part specifies requirements for treatment of hazardous waste in drums and tanks, and treatment of hazardous waste in land-based treatment units such as surface impoundments, waste piles and landfills. These requirements are relevant and appropriate to any onsite treatment of hazardous wastes. Treatment actions that occur in drums or tanks in less than 90 days must comply with the substantive requirements; however, the administrative requirement for a RCRA permit would not apply.

This part also sets forth the requirements for designating and managing corrective action management units (CAMUs) for the onsite management of media (i.e., soil, groundwater, sediment, etc) containing hazardous waste otherwise subject to the RCRA land disposal restrictions (LDRs). These regulations would be applicable if a CAMU designation is obtained for the Sites FTIR-38 Area 2 and 40 Area 1.1. A CAMU designation could potentially allow for the placement of wastes exceeding LDRs. The CAMU would have to meet construction standards as approved by the agencies; and long-term operation, maintenance, and monitoring would be required (until the CAMU is closed).

40 CFR 268. Part 268 identifies the wastes subject to LDRs and specifies the treatment standards that must be complied with prior to land disposal. Wastes exceeding these treatment standards are restricted from land disposal. These LDRs and treatment standards are applicable to hazardous wastes generated through onsite actions, such as excavation, drilling, and trenching.

Contained-In Policy (TBC).

The Contained-In Policy was first articulated in a November 13, 1986 memorandum, "RCRA Regulatory Status of Contaminated Groundwater". It has been updated multiple times in Federal Register preambles, EPA memos, and guidance (e.g., 53 FR 31138, 31142, 31148 (Aug. 17, 1988); 57 FR 21450, 21453 (May 20, 1992); a detailed discussion in HWIR-Media proposal preamble, 61 FR 18795 (April 29, 1996), and a description in Management of Remediation Waste Under RCRA (EPA, October 1998; EPA530-F-98-026).

Contaminated environmental media, in and of itself, is not a RCRA-regulated hazardous waste. Contaminated environmental media becomes regulated under RCRA only if it "contains" hazardous waste. EPA generally considers contaminated environmental media to contain hazardous waste when: (1) it exhibits a hazardous waste characteristic (corrosivity, ignitability, reactivity, or toxicity); or (2) it is contaminated with concentrations of constituents from a listed waste (F, K, U, or P codes) that are above health-based limits. Environmental media containing hazardous waste are subject to RCRA until they no longer contain the hazardous waste. The approval of EPA or an authorized state is required for a "contained-in determination" when the media was impacted with a listed waste to manage it as nonhazardous.

The contained-in policy is applicable to waste classification actions at the Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 when contaminated environmental media is generated through investigation and/or construction activities. In addition, this policy would be applicable to "contained-in determinations" if the media are treated such that they no longer exhibit the RCRA characteristics or contain concentrations of listed wastes above health-based limits.

Potential State Action-Specific ARARs and TBCs. The following state action-specific ARARs and TBCs have been identified for the Sites FTIR-38 Area 2 and FTIR-40 Area 1.1:

California Hazardous Waste Control Law; CCR Title 22, Division 4.5 - Environmental Health Standards for the Management of Hazardous Waste

This Division regulates the management of RCRA and non-RCRA (California) hazardous wastes, including classification, storage, treatment, disposal, and transport. The requirements of this Division are as stringent, and in some areas more stringent, than federal RCRA standards (which the State is authorized to administer).

<u>Chapter 11 (Identification and Listing of Hazardous Waste).</u> This chapter identifies the: (1) characteristics that solid wastes must exhibit to be classified as a RCRA or non-RCRA hazardous waste, and (2) the listed wastes which can result in classification as a RCRA or non-RCRA hazardous wastes – if contained in the environmental media. This chapter is applicable to environmental media that exhibit characteristics or contains concentrations of listed wastes above health-based levels, which is generated (i.e., removed from its original locations) through actions such as drilling, excavation, trenching, etc.

<u>Chapter 12 (Standards Applicable to Generators of Hazardous Waste).</u> This chapter establishes the requirements for hazardous waste management including labeling,

packaging, storage, accumulation time, and transport. This Chapter is applicable to management of hazardous wastes if they are generated through onsite actions such as drilling, excavation, trenching, etc The standards of this chapter would be relevant and appropriate to management of environmental media that is impacted but does not meet hazardous waste criteria.

Chapter 14 (Standards for Owners and Operators of Hazardous Waste Transfer, Treatment, Storage and Disposal Facilities. This chapter establishes the requirements for storage and/or treatment in tanks or containers, in addition to the standards for land-based units, such as waste piles and landfills. These standards would be applicable if onsite treatment of hazardous wastes occurs. [See Potential Action-Specific Federal ARARs and TBCs, RCRA - 40 CFR 264 description for CAMU discussion.]

Chapter 18 (Land Disposal Restrictions). Chapter 18 defines the wastes that are restricted from disposal in landfills and the treatment standards that must be met. These regulations are applicable to hazardous wastes that are generated onsite through actions such as drilling, trenching, and excavation which will be disposed of land-based units, such as landfills.

California Clean Air Act, San Bernardino Air Quality Management District (SBAQMD)Rule 403

The SBAQMD regulates emissions and restricts discharges of particulates. The SBAQMD regulations would also be applicable to soil excavations. Regulations specific to lead emissions would be relevant and appropriate to actions generating dust/particulates, such as excavations and earth moving

8.1.2.3 Potential Location-Specific ARARs. Federal, state, and regional location-specific ARARs are restrictions placed on the constituent concentration or the activities to be conducted at a site based on the location of the site Examples of special locations with potential ARARs include flood plains, fault zones, wetlands, historic places, and sensitive ecosystems or habitats. The location-specific ARARs for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 surface soils are listed in Table 3-7.

Potential Federal Location-Specific ARARs. The following federal location-specific ARARs have been identified for Sites FTIR-38 and FTIR-40:

Endangered Species Act (50 CFR 402)

The Act requires action to conserve endangered species and critical habitats upon which endangered species depend. Consultation with the USFWS is required to achieve compliance. This requirement is applicable to alternatives that will involve activities or impacts to areas used by the endangered species identified for the site, since several threatened and endangered or sensitive species (e.g. desert tortoise) have been identified at Ft. Irwin. A brief description of these plant and animal species is provided below.

Sensitive Species. The NTC Fort Irwin provides habitat for certain sensitive species. Sensitive plant species include all listed federal or state threatened, endangered, or otherwise sensitive species, and species considered to be rare or declining by the California Native Plant Society. Sensitive wildlife species include all listed federal and state threatened and endangered species, species that are candidates for such listing, and California Species of Special Concern (CSC).

An Endangered Species Management Plan (ESMP) is currently being prepared for all listed endangered, threatened, or otherwise sensitive wildlife and plant species on the NTC. In addition, a Programmatic Management Plan (PMP) for the desert tortoise was prepared to guide the management of the desert tortoise at the NTC. These documents are to be used as a guide for the continued preservation and management of the desert tortoise and other sensitive species and their habitats within the NTC.

The descriptions below were excerpted from the Phase I ERA (Montgomery Watson, 1998).

Plants. Federally listed plants are discussed below. There are no state-listed plant species on the NTC

Lane mountain milk vetch (*Astragalus jaegerianus*) - Federally Proposed Endangered. Lane mountain milk vetch is a fabaceous perennial herb threatened by grazing and vehicles, and potentially by maneuvers at Fort Irwin. It occurs in Joshua tree woodland and creosote bush scrub in poorly developed granitic, sandy, or gravelly soils. Two populations are known from the Goldstone area. The land Mountain and Goldstone areas, and the contiguous area on the NTC include the entire known existing and historic range of the species.

Wildlife. Wildlife currently listed as threatened or endangered by state or federal agencies are discussed in detail below.

Desert Tortoise (*Gopherus agassizii*). The desert tortoise is a large, herbivorous reptile found throughout much of the Mojave and Sonoran deserts; its range roughly approximates the distribution of creosote bush scrub. The desert tortoise spends much of the year underground to avoid the extreme temperatures during the summer and winter. It constructs and maintains single-opening burrows, of which there may be several within an individual's home range. The desert tortoise is active in the spring, summer and autumn when daytime temperatures are below 90 degrees Fahrenheit (°F) (32 degrees Celsius [°C]). Most activity occurs during spring and early summer when most wildflowers bloom.

The USFWS determined that the desert tortoise warranted listing in response to documented population declines over large portions of its range. The decline is thought to be due to a number of reasons, including upper respiratory tract disease exacerbated by the stress of several drought seasons, loss of habitat, predation by ravens, livestock grazing, and direct disturbance by humans. The USFWS emergency-listed the desert tortoise on 4 August 1989, and officially listed the Mojave population as federally threatened in April 1990.

The desert tortoise on the NTC is well studied. Numerous surveys have been conducted over the past years to document the distribution and estimated size of tortoise populations throughout the NTC. The desert tortoise is known to occur throughout the NTC in low to moderate numbers, with the highest concentration along the southern boundary.

As fully described in the PMP and the ESMP, the NTC Fort Irwin has adopted a series of programs intended to benefit the desert tortoise. Each program undertaken on behalf of the desert tortoise at Fort Irwin contributes to a better understanding of the species and the conservation and preservation of the species as a whole. These programs include education programs for military and civilian personnel, juvenile tortoise research, reconnaissance-level surveys for the tortoise as well as other general sensitive plant and wildlife species, and long-term studies that include desert tortoise monitoring plots, tortoise relocation, upper respiratory tract disease, neonatal information, and desert tortoise predation.

California Black Rail (*Laterallus jamaicensis coturniculus*). The California black rail is listed as threatened by the CDFG. The species is a very uncommon, local breeder inhabiting marshes, swamps, and wet meadows. Two large, disjunct populations occur in California: one in the San Francisco Bay area and the other along the Colorado River drainage in Imperial County. The black rail was observed at the sewage treatment ponds on the NTC during the fall of 1994, but it has not been seen since. The occurrence of the species at the sewage ponds on the central Mojave desert is extremely unusual.

Swainson's Hawk (*Buteo swainsoni*) - State Threatened. The Swainson's hawk was once a widespread breeder in the non-forested areas of northern California and in the Central Valley. Conversion of the Central Valley and other grassland areas from pastureland to cropland has probably been a major factor in the population's decline. The Swainson's hawk winters in South America. This species is migratory and not expected to occur regularly at the NTC or forage in the area for prolonged periods.

Southwestern Willow flycatcher (*Empidonax traillii extimus*) - State and Federally Endangered. The southwestern willow flycatcher is a summer resident species in the region that breeds in riparian woodland habitats consisting of willows, cottonwoods and/or alders. This species is not expected to occur regularly on the NTC because of the lack of appropriate habitat. It may occur at the springs during brief periods of migration.

Potential State Location-Specific ARARs. The following state location-specific ARARs have been identified for the Sites FTIR-38 Area 2 and FTIR-40 Area 1.1:

California Endangered Species Act of 1984 and California Native Plant Protection Act; Fish and Game Code, Chapter 15, Article 15, Section 2090.

The Code contains a requirement to obtain written findings from the State Department of Fish and Game regarding the impact of disturbances on the viability of an endangered population. This requirement is applicable to alternatives that include disturbance (i.e., construction or excavation) of the locations used by endangered or sensitive species described above. The southwestern willow flycatcher (*Empidonax traillii extimus*) is a State and Federally listed 'Endangered' species that has been observed at Fort Irwin; and the Mojave ground squirrel (*Spermophilus mohavensis*) and golden eagle (*Aquila chrysaetos*) are State 'Special Status' species.

In addition to the federal and state location-specific ARARs, there are permitting and construction standards specific to San Bernardino County that must be considered. Once the alternative is selected, these standards will be addressed in the final remedial design report.

8.1.2.4 Additional Requirements. Additional requirements established by State and local laws that may have bearing on the selection of the remedial action include:

- County construction permits and standards
- County hazardous materials permits and standards
- Health and safety standards

The applicable requirements for these standards are discussed in the following sections.

Proposition 65. This proposition, the Safe Drinking Water and Toxic Enforcement Act of 1986 (Prop 65), resulted in regulations requiring, but not limited to (1) an annual listing of chemicals known to the State to cause cancer or reproductive toxicity (updated annually); and (2) warnings. Requirements of Proposition 65 could be applicable to alternatives if:

a) Compounds in the soil and groundwater are identified as chemicals known to the State to cause cancer and/or reproductive toxicity

b) There are complete exposure routes.

Individuals working with treatment systems and/or on-site during remedial construction could be exposed to soil and groundwater with organic or inorganic contaminants. Warnings would be required pursuant to 22 CCR 12601(d) for occupational exposure scenarios through the posting of warning signs to include the pertinent language as follows:

WARNING: This area contains a chemical known to the state to cause [cancer and/or reproductive toxicity].

A warning would also be presented in the site health and safety plan addressing the requirements of the federal Hazard Communication Standard (29 CFR 1910.120 and 8 CCR 5194). All warnings for occupational exposures must be provided in compliance with 22 CCR 12601(c).

Construction and Building Permits. All construction work must be performed in accordance with applicable county codes and requirements. In addition, all relevant permits must be secured before construction begins. If trenching is deeper than 5 feet, then an annual trench and excavation permit from California Occupational Safety and Health Administration (Cal-OSHA) will be necessary. All trenching and excavation will comply with applicable standards as set by Cal-OSHA.

Health and Safety. The remedial alternative must be consistent with respective standards and references regarding health and safety, such as:

Uniform Fire Code and National Fire Protection;
Association Uniform Building Code;
National Electric Code; and
Cal-OSHA.

8.2 REMEDIAL ACTION OBJECTIVES AND SITE-SPECIFIC CLEANUP LEVELS

This section presents the RAOs and SSCLs based on the ARARs, TBCs, and results of human health and ecological risk assessments for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1. The RAOs are the goals of any remedial action and are intended to be protective of human health and the environment. According to USEPA (1988), the RAOs are media-specific and area-specific goals for protecting human health and the environment that specify:

- The contaminants of concern

- The exposure route and receptors
- An acceptable contaminant level or range of levels for each exposure route (i.e., site-specific cleanup goals)

Section 8.1 summarized the COCs, and potential COECs in surface soils for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1; namely aluminum, cadmium, copper, lead, and zinc. The exposure routes for consideration of human health impacts included incidental soil ingestion, dermal contact, and inhalation. Those exposure pathways for consideration of ecological impacts included direct ingestion of plants containing these constituents, indirect ingestion of soil, and dermal contact with soil. Site-specific cleanup levels will be developed based on information developed in the HHRA (Section 6.0) and the ERA (Section 7.0).

8.2.1 Remedial Action Objectives

The RAOs are designed to be protective of human health and the environment. USEPA (1988) stated that "the final acceptable exposure levels should be determined on the basis of the results of the baseline risk assessment and the evaluation of the expected exposures and associated risks for each alternative." The baseline HHRA and ERA are now complete and have been presented in Sections 6.0 and 7.0 respectively. Site-specific parameters from these sections will be used to set media-specific cleanup goals for impacted surface soils.

The conceptual site models developed for human and ecological receptors associated with Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 were presented in Sections 6.0 and 7.0. The conceptual site model identifies the compounds in the environment, their potential routes of migration in environmental media, and the potential exposure pathways between human or animal receptors and impacted media. Relevant exposure pathways for human and ecological receptors are described in more detail below

Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 will be used by NASA for its Deep Space Satellite Tracking Station and as habitat for indigenous wildlife. Therefore, RAOs will focus on the protection of future industrial workers and ecological receptors, as described in the HHRA (Section 6.0) and ERA (Section 7.0), respectively.

The RAOs for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 are:

- Prevent direct contact (i.e., ingestion, dermal contact, and inhalation exposure) by industrial workers to COCs in surface soils (0 to 1 foot) in excess of site-specific cleanup goals.
- Prevent direct contact (i.e., ingestion of impacted plants, dermal contact, and incidental soil ingestion) by ecological receptors to concentrations of COECs excess of site-specific cleanup goals for surface soil (0 to 3.5 feet).

8.2.2 Site-Specific Cleanup Levels

The SSCLs for soils associated with Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 are presented in this section. These cleanup goals will consider the ARARs and TBCs developed in Section 8.1 (including background soil chemical conditions), COCs for surface soils (0 to 1 foot) developed in Section 6.0, and potential COECs for surface soils (0 to 3.5 feet) developed in Section 7.0. The SSCLs for soils are based on industrial land use and wildlife habitat

8.2.2.1 Constituents of Concern. In Sections 2, 3, and 4, the RI identified lead as the indicator compound for artillery and other metal debris in soils. Other potential COECs (i.e., aluminum, cadmium, copper, and zinc) are co-located with lead at Sites FTIR-38 Area 2 and FTIR-40 Area 1.1. Therefore, characterization and remediation of lead in soils would also address these other potential COECs.

The HHRA (Section 6.0) identified lead in surface soil (0 to 1 foot), as the only COC that required further evaluation in the FS based on the industrial land use scenario. Subsurface soils (below 1 foot) were evaluated but did not exceed risk-based criteria for industrial land use.
The Phase II Validation Study (Section 7.0) identified five potential COECs in surface soils (0 to 3 feet), including lead, aluminum, copper, cadmium and zinc. To further refine potential

COECs, SSLs, BUTLs for Fort Irwin soils, and risks based on BTAG low TRVs, BTAG high TRVs, and Army TRVs were evaluated Based on these criteria (summarized in Table 8-1), the Army TRVs were selected as the criteria upon which final COECs would be selected because risks based on Army TRVs fell in between those calculated using BTAG low and BTAG high TRVs, but still favored a minimal level of potential effects. On this basis, lead, copper, and aluminum were retained as COECs, with cadmium and zinc eliminated from further consideration.

8.2.2.2 Background Metals Concentrations in Soils. A background constituent (for example lead or arsenic in soils) often exceeds the most conservative human health or ecological risk based remediation standards. Therefore, RAOs and SSCLs cannot always achieve risk-based standards without massive soil removal, habitat destruction and imported soil fill that may not be compatible with the native plant and animal communities The background concentrations of COCs and COECs presented in Table 8-1 were derived from analysis of background soil samples (Parsons ES, 1996) and reference samples selected by CDFG, as discussed in Section 4.0 and presented in Table 4-1.

8.2.2.3 Development of Site-Specific Cleanup Levels. Table 8-4 presents a summary of SSCLs for Site FTIR-38 and Site FTIR-40 surface soils for human health, ecological risks, background conditions, ARARs and TBCs discussed in Sections 8.1 and 8.2. The SSCLs for surface soils are based on anticipated future land uses described in Section 6.3.1 and the risk characterization results presented in Section 6.5 for human health and Section 7.6 for ecological risks. The anticipated land uses for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 include industrial land use and wildlife habitat.

The SSCLs for COCs and COECs were developed by evaluating human health and ecological toxicity information developed in the HHRA and ERA, and also considering background constituent concentrations present at the site. Human health risk-based cleanup levels for lead are presented in Table 8-4 and were developed using Cal-EPA's *Lead Risk Assessment Spreadsheet* (Bloodpb7.xls). Default exposure parameters for background intakes of lead in air, water, and diet were considered, and the 99th percentile for industrial receptors was calculated as the human health risk-based SSCL for lead. Based on the above, the human health risk-based SSCL for lead for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 surface soils was calculated as 3,475 mg/kg.

Ecological risk-based cleanup levels for COECs were based on a HQ of 1.0, using soil ingestion, soil to plant transfer coefficients, food ingestion, dermal exposure, and Army TRVs, presented in Section 7.0. Based on the above, ecological risk-based cleanup levels for COECs are presented in Table 8-4. Note that the ecological risk-based standard for aluminum is 605 mg/kg, which is less than the BUTL value of 23,600 mg/kg. Therefore, the BUTL for aluminum was selected as the SSCL for this constituent.

Figures 8-1 and 8-2 present areas of Sites FTIR-38 and FTIR-40 that exceed the SSCLs presented in Table 8-4. The areas presented in Figures 8-1 and 8-2 will be evaluated further in the remainder of the FS.

9.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

This section presents the identification and screening of remedial technologies intended to address the RAOs and SSCLs at Sites FTIR-38 Area 2 and FTIR-40 Area 1.1. Remedial technologies that can achieve the RAOs identified in Section 8.0 which also satisfy the screening criteria described in this section will be further developed and evaluated in Section 10.0. Conversely, those remedial technologies that cannot meet the RAOs and SSCLs will be eliminated from further consideration. The purpose of this screening process is to evaluate potentially effective remedial technologies and eliminate those technologies that do not meet RAOs and SSCLs or cannot be implemented at Sites FTIR-38 Area 2 and FTIR-40 Area 1.1.

9.1 IDENTIFICATION OF RESPONSE ACTIONS AND REMEDIAL TECHNOLOGIES

A general response action (GRA) includes no action, institutional controls, containment, removal/disposal, or treatment. The response actions are further defined to specify remedial technologies in each GRA category i.e., capping, excavation, and in-situ stabilization. Single remedial technologies or multiple technologies may achieve RAOs developed for Sites FTIR- 38 Area 2 and FTIR-40 Area 1.1.

Table 9-1 presents GRAs developed for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1, that are capable of achieving the RAOs. Each GRA will be considered during screening of corrective measure alternatives for soil, as discussed in Section 9.3. As required by CERCLA, the no action will be carried through the identification and screening of alternatives for purposes of comparison. Detailed descriptions of each remedial technology listed in Table 9-1 are presented in Appendix O.

9.2 SCREENING CRITERIA

Each GRA identified in Table 9-1 was screened based on effectiveness, implementability, and relative cost. These screening criteria are defined as follows:

- Effectiveness. This criterion focuses on the degree to which an alternative reduces toxicity, mobility, or volume through treatment. Effective remedies minimize residual risks and afford long-term protection. Potentially effective GRAs comply with ARARs, minimize short-term impacts, and quickly achieve RAOs.

- Implementability. This criterion focuses on the site constraints, and the technical and administrative feasibility of implementing the alternative.

- Cost. Construction, engineering, and administrative costs, along with any long-term costs to operate and maintain the alternatives are considered. Cost alone will not be used to eliminate any GRA. Alternatives that provide similar effectiveness and implementability can be eliminated based on cost. Costs estimates are based on standard construction rates.

9.3 SCREENING OF RESPONSE ACTIONS AND REMEDIAL TECHNOLOGIES

This section provides the screening evaluation of the GRAs developed in Section 9.1 using the screening criteria described in Section 9.2. The remedial technologies are screened based on the criteria described above using professional experience, published references, and other available documentation.

Table 9-1 summarizes the results of the screening evaluation. Appendix O provides detailed descriptions, evaluations, and screening comments for the remedial technologies presented in Table 9-1. The technologies considered in Table 9-1 encompass the most comprehensive and appropriate technologies based on the current understanding of the nature and extent of contamination, risk assessments, and contaminant fate and transport evaluation for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1.

In Table 9-1, when a GRA or remedial technology option could successfully attain the RAOs and satisfy all screening criteria, it was identified as a "Retained" response action or remedial technology. When a GRA or remedial technology failed to meet one or more screening criteria but could be used in conjunction with other response actions or technologies was identified as "Retained as Support" response action or remedial technology. Those remedial technologies that failed all screening criteria were eliminated from further consideration and identified as "Eliminated".

Table 9-1 provides the detailed rationale for retaining or eliminating remedial technologies. A brief summary is provided below:

- No action and institutional controls were retained for further consideration.
- Containment with a native soil cover was retained for further consideration.
- Other containment technologies were eliminated due to difficulty in implementation and high cost.
- Excavation and off-site disposal was retained for further consideration.
- Excavation and on-site disposal was eliminated because it may require construction of an on-site landfill.
- Screening or separation would result in significant habitat disturbance and would not be effective in protecting human health and ecological receptors, and were eliminated.
- Surface debris removal was retained as a support technology that may be implemented for aesthetic reasons.
- Soil washing and ex-situ stabilization were eliminated due to difficulty in implementation and high cost.
- In-situ stabilization would not be protective of ecological receptors, and was therefore eliminated.

9.4 SUMMARY OF RETAINED REMEDIAL TECHNOLOGIES

The remedial technologies that have been retained for the development of remedial alternatives are summarized in Table 9-2. These technologies include: soil removal, debris removal, containment by engineered soil cover, in addition to no action and institutional controls.

10.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

In this section, the remedial technologies that were retained from the technology screening process described in Section 9.0 are assembled into a range of remedial alternatives capable of addressing the RAOs developed for Sites FTIR-38 Area 2 (soil berms) and FTIR-40 Area 1.1 (waste pile). Remedial alternatives are discussed in detail for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 in Sections 10.1 and 10.2, respectively. These alternatives will be evaluated against the nine criteria established by USEPA in Section 11.0.

10.1 REMEDIAL ALTERNATIVES FOR SITE FTIR-38 AREA 2

This section describes the three remedial alternatives developed for Site FTIR-38 Area 2. The soil berms at this site contain five "hot spots". Each hot spot contains lead or aluminum concentrations above RAOs.

The remedial alternatives developed for Site FTIR-38 Area 2 are:

- Alternative 1 – No Action
- Alternative 2 – Institutional Controls
- Alternative 3 – Removal/Disposal

These alternatives are summarized in the following subsections.

10.1.1 Alternative 1 - No Action

The no action alternative provides a baseline for comparison with other alternatives. Five-year site reviews are included in this alternative, per CERCLA guidance (USEPA, 1988). Site reviews include site walks and evaluation of current land use.

10.1.2 Alternative 2 - Institutional Controls

This alternative includes access and land use restrictions around the areas where elevated concentrations of metals have been detected at Site FTIR-38 Area 2. Access restrictions include site security and installation of warning signs. Land use restrictions have been developed and are enforced by the planning group at Fort Irwin through the use of a Master Plan. Currently, there are no future plans for further use of Site FTIR-38. If ownership of the base is transferred to private or non-federal entities, land use restrictions would be established to maintain this area for industrial use only. In addition, as part of institutional controls, annual population counts will be conducted on the Mojave ground squirrel.

10.1.3 Alternative 3 – Removal/Disposal

This alternative involves the excavation of soil contaminated with metals at Site FTIR-38 Area 2. Approximately 180 cubic yards of soil would be excavated and transported to an off-site disposal facility. Based on soil contaminant concentrations detected at this site, it is assumed that the excavated soil will be disposed at a Class I hazardous waste landfill, as indicated by TCLP sample results presented in Table 10-1.

Prior to excavation, the entire work area will be cleared for UXO by experienced personnel, haul routes will be established and constructed, and all relevant permits will be in place. In addition, all surface debris in the work area will be removed and disposed of appropriately to reduce the risk of injury to humans and native habitat and to improve the aesthetics of the site. Soils impacted by lead and aluminum above the SSCLs described in Section 8.0 and Table 8-4 will be removed from Site FTIR-38 Area 2. Soil removal will be accomplished with a backhoe or excavator equipped with an explosion proof shield. During soil removal actions, dust control will be implemented by use of water.

By reducing the volume of impacted soils, the potential risks to human health and ecological receptors would be reduced. However, there will be typical physical hazards to construction personnel working at the site during excavation activities. The potential hazards include UXO, operation of heavy equipment, working around open excavations, and the potential for inhalation of airborne lead particulates. Personal protective equipment and environmental controls such as dust control, would be used to eliminate these hazards.

Following excavation activities, confirmation soil samples will be collected and analyzed for contaminates of concern to determine if RAOs and SSCLs have been met. Analysis using the XRF method (described in Section 3.4) will be considered. Additional excavation will be required if RAOs and SSCLs have not been satisfied following initial excavation.

Similar to Alternative 2, this alternative includes access and land use restrictions since soils impacted with lead and aluminum will be left in place. Access restrictions include site security and installation of warning signs. Land use restrictions have been developed and are enforced by the planning group at Fort Irwin through the use of a Master Plan. Currently, there are no future plans for further use of Site FTIR-38. If ownership of the base is transferred to private or non-federal entities, land use restrictions would be established to maintain this area for industrial use only.

10.2 REMEDIAL ALTERNATIVES FOR THE SITE FTIR-40 AREA 1.1 WASTE PILE

This section describes the five remedial alternatives developed for the Site FTIR-40 Area 1.1 waste pile. The soil at this site contains metal contamination where lead and copper were detected above their respective cleanup levels.

The remedial alternatives developed for the Site FTIR-40 Area 1.1 waste pile are:

- Alternative 1 – No Action
- Alternative 2 – Institutional Controls
- Alternative 3 – Surface Debris Removal with Institutional Controls

- Alternative 4 – Limited Soil Removal to 3.5 Feet and Backfill with Imported Soil
- Alternative 5 – Clean Closure

These alternatives are evaluated in Table 10-1 and described in the following subsections.

10.2.1 Alternative 1 - No Action

The no action alternative provides a baseline for comparison with other alternatives. Five-year site reviews are included in this alternative, per CERCLA guidance. Site reviews include site walks and evaluation of current land use.

10.2.2 Alternative 2 - Institutional Controls

This alternative includes access and land use restrictions around the areas where elevated concentrations of metals have been detected at the Site FTIR-40 Area 1.1 waste pile. Access restrictions include site security and the installation of warning signs. Land use restrictions have been developed and are enforced by the planning group at Fort Irwin through the use of a Master Plan. Currently, there are no future plans for further use of Site FTIR-40. If ownership of the base is transferred to private or non-federal entities, land use restrictions would be established to maintain this area for industrial use only.

10.2.3 Alternative 3 - Surface Debris Removal with Institutional Controls

This alternative includes the same components as Alternative 2 with the addition of surface debris removal. All surface debris at the site will be removed by hand and disposed of appropriately to reduce the risk of injury to humans and native habitat and to improve the aesthetics of the site. The access and land use restrictions included in this alternative is the same as that described for Alternative 2 in Section 10.3.3.

10.2.4 Alternative 4 – Limited Soil Removal to 3.5 Feet and Backfill with Imported Soil

This alternative consists of excavating 640 cubic yards of debris and contaminated soil and backfilling the excavation with clean soil. Debris and soil would be excavated to a depth of 3.5 feet bgs and transported to an off-site disposal facility. Any debris and contaminated soil below a depth of 3.5 feet would be left in place. The depth of 3.5 feet was selected based on the maximum burrowing depth of the Mojave ground squirrel of 3.5 feet, as discussed in Section 7.0.

It is assumed that the soil will be disposed at a Class I hazardous waste landfill. Clean soil, imported from off-site, would be backfilled to replace the excavated soils. The imported soil cover would cover the entire excavated area and graded to prevent ponding. The primary purpose of the soil cover is to provide a separation layer that would prevent direct contact with impacted soil. The soil cover would serve as a root zone for native vegetation.

Prior to excavation, the entire work area will be cleared for UXO by experienced personnel, haul routes will be established and constructed, and all relevant permits will be place. Soil removal will be accomplished with a backhoe or excavator equipped with an explosion proof shield. During soil removal actions, dust control will be implemented by use of water.

By reducing the volume and toxicity of contaminants at this site, the potential risks to human health and ecological receptors would be reduced. However, there will be several potential hazards to construction personnel working at the site during excavation activities. The potential construction hazards include UXO, operation of heavy equipment, working around open excavations, and the potential for inhalation of airborne contaminants. Personal protective equipment and environmental controls such as dust control would be used to eliminate these hazards.

This alternative meets the intent of ARARs and achieves the RAOs and SSCLs of reducing adverse impacts to the most sensitive ecological receptors. As with the institutional controls alternative, this alternative includes access and land use restrictions since waste and soils potentially impacted with lead and copper will be left in place. Access restrictions include site security and installation of warning signs. Land use restrictions have been developed and are enforced by the planning group at Fort Irwin through the use of a Master Plan. Currently, there are no future plans for further use of Site FTIR-38. If ownership of the base is transferred to private or non-federal entities, land use restrictions would be established to maintain this area for industrial use only.

10.2.5 Alternative 5 – Clean Closure

This alternative involves the excavation of soil contaminated with metals at the Site FTIR-40 Area 1.1 waste pile to meet the cleanup levels for lead and copper. Approximately 1,700 cubic yards of soil would be excavated and transported to an off-site disposal facility. This volume of soil is based on a depth of waste of approximately 10 feet bgs. Based on the soil contaminants detected at this site, it is assumed that the excavated soil will be disposed at a Class I hazardous waste landfill.

Prior to excavation, the entire work area will be cleared for UXO by experienced personnel, haul routes will be established and constructed, and all relevant permits will be place. Soils contaminated with lead and copper above the cleanup goals will be permanently removed from Site 40 Area 1.1. Soil removal will be accomplished with a backhoe or excavator equipped with an explosion proof shield. During soil removal actions, dust control will be implemented by use of water.

By reducing the volume and toxicity of contaminants at this site, the potential risks to human health and ecological receptors would be reduced. However, there will be typical construction hazards to construction personnel working at the site during excavation activities. These hazards include UXO, operation of heavy equipment, working around open excavations, and the potential for inhalation of airborne lead particulates. Personal protective equipment and environmental controls such as dust control, would be used to eliminate this risk. This alternative meets the intent of ARARs and achieves the RAOs and SSCLs of reducing adverse impacts to the most sensitive ecological receptors.

Following excavation activities, confirmation soil samples will be collected and analyzed for contaminates of concern to determine if RAOs have been met. Additional excavation will be conducted until impacted material has been removed.

11.0 DETAILED ANALYSIS OF ALTERNATIVES

The purpose of the detailed analysis is to provide a thorough analysis of options, considering the relevant information needed to choose a site remedy. During the detailed analysis, each alternative, including a no action alternative for comparison, is assessed against nine criteria developed by the USEPA (USEPA, 1988). The definition of these criteria is presented in Section 11.1. The detailed analyses of alternatives for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 waste pile are presented in Sections 11.2 and 11.3, respectively. The alternatives developed and described in Section 10.0 are evaluated using all nine criteria for both sites. The preferred alternative for each site is presented in Section 12.0.

11.1 CRITERIA FOR DETAILED ANALYSIS

The USEPA has developed nine criteria for evaluating remedial alternatives at CERCLA sites (USEPA, 1988). These criteria are considered individually and are equally weighted for importance. Based on their specific functions during remedy selection, the evaluation criteria have been divided into three groups: the threshold criteria, the balancing criteria, and the modifying criteria.

The threshold criteria relate to statutory requirements that each alternative must satisfy in order to be eligible for selection. These are:

- *Overall Protection of Human Health, Ecological Receptors and the Environment.* Under this criterion, an alternative is evaluated in terms of how it achieves and maintains overall protection of human health, ecological receptors, and the environment.
- *Compliance with ARARs and RAOs.* Under this criterion, an alternative is evaluated in terms of its compliance with federal and state action-specific, chemical-specific, and location-specific ARARs and RAOs, or if a waiver is required, how it is justified.

The balancing criteria are the significant technical criteria that are considered during the detailed analysis. These are:

- *Long-Term Effectiveness* Under this criterion, an alternative is evaluated in terms of its long-term effectiveness in maintaining protection of human health, ecological receptors, and the environment after the RAOs have been met The magnitude of the residual and the adequacy and reliability of controls are taken into consideration.

- *Reduction of Toxicity, Mobility, or Volume (TMV) Through Treatment.* Under this criterion, an alternative is evaluated in terms of the anticipated performance of the specific treatment technologies it employs. Factors such as the volume of the materials destroyed or treated, the degree of expected reductions, the degree to which treatment is irreversible, and the type and quantity of remaining residuals are taken into consideration.

- *Short-Term Effectiveness.* Under this criterion, an alternative is evaluated in terms of its effectiveness in protecting human health, ecological receptors, and the environment during the construction and implementation of a remedy before the RAOs have been met The time it takes to meet the RAOs is also taken into consideration.

- *Implementability.* Under this criterion, an alternative is evaluated in terms of its technical and administrative feasibility and the availability of required services and materials. Also considered are the reliability of the alternative components, the ability to monitor the effectiveness of the remedy, and the ease of undertaking additional remedial actions, if necessary.

- *Cost.* The cost evaluation is based upon estimates for capital costs and annual operation and maintenance (O&M) costs Capital costs typically include the costs for design, construction, equipment, mobilization, decommissioning, and any O&M costs that occur within the first year (e.g., equipment rental, labor, analytical costs, transportation, and disposal fees). O&M costs include those costs that occur after the first year, such as 5-year site reviews

Because the alternatives may have differing implementation time frames, a present-value has been calculated for each based on an annual discount rate of 7 percent, with an accuracy range of +50 to –30 percent (USEPA, 2000b). The present-value analysis provides a single figure representing the amount of money that, if invested in the base year and dispersed as needed, would cover all costs associated with the alternative. The present-value calculation normalizes alternatives that have differing operating lifetimes, thus facilitating comparisons. It should be noted that all "total project duration" values start at the time that capital and other equipment are delivered to the site It is assumed that procurement and design for all systems considered will be similar.

It should be noted that the cost estimates evaluated in this FS have been developed or the purpose of comparing alternatives Specific cost estimates are based on site factors and a conceptual design, not on a detailed design. Consequently, the list of equipment may not be complete and the total estimated costs might not reflect actual costs that may be incurred during the remediation project. Also, the estimated costs assume no changes in regulatory requirements and technologies affecting the remedial activities.

The modifying criteria take into account the issues and concerns of the state and community, which are formally evaluated after the public comment period. However, state and community views are considered during the evaluation process to the extent that they are known. The modifying criteria are:

- *State Acceptance*. Under this criterion, an alternative is evaluated in terms of how it is accepted by the state. The technical and administrative issues and concerns that the state may have, are taken into consideration.
- *Community Acceptance*. Under this criterion, an alternative is evaluated in terms of how it is accepted by the community. The technical and administrative issues and concerns that the community may have are taken into consideration.

11.2 SITE FTIR-38 AREA 2

In this section, three alternatives described for Site FTIR-38 Area 2 in Section 10.2 are evaluated. A brief summary of these alternatives is provided below Table 11-1, and Sections 11.2.1 to 11.2.8 present the detailed analysis for these three options.

- Alternative 1 - No Action - Five-year site reviews are very easily implementable. However, the no action alternative meets neither the ARARs nor the RAOs because this alternative does not reduce the toxicity, mobility, or volume of impacted soil. Additionally, the risks to human health and the environment, including plants and burrowing mammals, at Site FTIR-38 Area 2 would not be reduced. The 5-year present-value of the no-action alternative is $7,000 (Table P-1).

- Alternative 2 - Institutional Controls - As with the no-action alternative, this alternative does not reduce the toxicity, mobility, or volume of the contaminants in the soil. However, this alternative relies on control measures to prevent access or exposure to contaminated areas at the site. By implementing access and land use restrictions, this alternative would be protective of human health under the current and future land use scenarios. Potential adverse impacts to ecological receptors, though, will remain. As part of institutional control alternative, annual population counts will be conducted on the Mojave ground squirrel. Although this option would comply with the intent of most ARARs, it does not achieve the RAOs. Cooperation between the Army and the appropriate regulatory agencies would be required to enact land use restrictions. The 5-year present-value of the institutional controls alternative is $113,000 (Table P-2).

- Alternative 3 - Removal/Disposal – Alternative 3 meets the intent of all ARARs and achieves RAOs by reducing the toxicity, mobility, and volume of the contaminants in the soil. Conventional equipment can be used to excavate the soil and is readily available. Transportation and disposal of soils at an approved disposal facility are easily implementable. Land use restrictions would still be required following soil removal. Potential human health and ecological risks would be reduced to acceptable levels. The 5-year present worth of this alternative is $440,000 (Table P-3).

In conducting the detailed analysis of alternatives, the expected performances of the three alternatives are evaluated according to the nine evaluation criteria mentioned above. The detailed analysis of alternatives for Site FTIR-38 Area 2 is summarized in Table 11-1.

11.2.1 Overall Protection of Human Health, Ecological Receptors, and the Environment

As discussed in the baseline HHRA presented in Section 6.0, lead in surface soil is identified as a COC. The 99th percentile blood-lead estimate for industrial workers (i.e., 10.5 ug/dl) would exceed the acceptable blood-lead criterion of 10 µg/dl. Therefore, Alternative 1, No Action, would not achieve the RAOs and SSCLs for lead in surface soil. The Phase II Ecological Validation Study (presented in Section 7.0), identified a potential ecological impact at Site FTIR-38 Area 2 for small mammals, specifically the Mojave ground squirrel. Aluminum was identified as a COEC for Site FTIR-38 Area 2. The ecological HQ estimate for this COEC would remain > 1.0. Therefore, Alternative 1, No Action, would not achieve the RAOs and SSCLs for aluminum.

Alternative 2, Institutional Controls, provides the minimum action necessary to protect human health (i.e., by reducing the potential for direct contact with soil impacted with metals through land use restrictions and restricted access) for both current and future industrial land use conditions. The 99th percentile blood-lead estimate for industrial workers would be less than the acceptable blood-lead criterion of 10 ug/dl, as a result of decreased exposure. Although this alternative would achieve acceptable human health risk levels, it does not protect ecological receptors beyond Alternative 1 Ecological HQ estimates for COECs would continue to be > 1.0

Alternative 3, Removal/Disposal is more protective of human health and ecological receptors because direct contact with lead and aluminum impacted soil is significantly reduced. Background concentrations of aluminum would be achieved; therefore the residual ecological hazard associated with this COEC would be acceptable. For lead, the residual ecological HQ estimate (i.e., 0.9) is less than the ecological HQ criterion of 1.0, and the 99th percentile blood-lead estimate for industrial workers (i.e., 3.6 ug/dl) is less than the acceptable blood-lead criterion of 10 ug/dl. Therefore, Alternative 3 is considered to be the most protective of human health and ecological receptors.

11.2.2 Compliance with ARARs

Alternative 1, No Action, does not comply with ARARs or achieve RAOs. Alternative 2, Institutional Controls, complies with and meets the intent of most ARARs; however, institutional controls does not achieve RAOs and SSCLs. Alternative 3, Removal/Disposal, meets the intent of ARARs and achieves RAOs by excavating and removing soil impacted with metals above SSCLs.

11.2.3 Long-Term Effectiveness

Alternative 1 does not satisfy the RAOs because the impacted soil volume remains unchanged Alternative 2 satisfies the RAOs under the current land use scenario but does not satisfy the RAOs for preventing direct contact with soil impacted with metals. Alternative 3 satisfies all of the RAOs for the current industrial land use scenario. However, excavation and soil removal to RAOs requires five-year site reviews and a land use restrictions.

11.2.4 Reduction of Toxicity, Mobility, and Volume

Alternatives 1 and 2 do not actively reduce the TMV of metal impacted soils. However, the mobility of metals at Site FTIR-38 Area 2 are considered to be minimal as discussed in Section 5.0.

11.2.5 Short-Term Effectiveness

Alternatives 1 and 2 are not expected to adversely impact human health and the environment during implementation

Alternative 3 would present some potential physical hazards to remediation workers, due to the potential to encounter UXO UXO avoidance using trained professionals is included in all alternatives that require intrusive activities to limit the health and safety risk. Additional risks involve working with and around heavy equipment near open excavations and inhalation of air borne particulates.

Implementation of Alternative 3 would minimally impact the environment by modifying the natural site conditions. Revegetating the site with quick-growing grasses may alleviate some of the impact until natural vegetation can return.

11.2.6 Implementability

Alternatives 1 and 2 are easily implemented at Site FTIR-38 Area 2. Alternative 3 is slightly more difficult to implement because earth-moving equipment with explosion shields and dedicated UXO avoidance crews are required on site during all intrusive activities. Simple earth moving activities are expected to take 1.5 to 2 times as long under these conditions.

11.2.7 Cost

Cost estimates for each of the three alternatives are presented in Tables P-1 through P-3 (Appendix P). These tables provide a detailed list of the components included in the cost estimates. These costs are summarized in Table 11-1.

In general, the estimated present value increases from Alternative 1 to Alternative 3 due to successive additions of component technologies. Alternative 1 costs $7,000, Alternative 2 costs $113,000, and Alternative 3 costs $440,000.

11.2.8 State and Community Acceptance

The no action alternative would likely be acceptable to the public because of the remote location of Site FTIR-38 Area 2. The state may request involvement in land use restrictions.

11.3 SITE FTIR-40 AREA 1.1

In this section, five alternatives described for Site FTIR-40 Area 1.1 in Section 10.3 are evaluated. A brief summary of these alternatives is provided below. Sections 11.3.1 to 11.3.8 present the detailed analysis for these five options

- Alternative 1 – No Action - Five-year site reviews are very easily implementable. However, the no action alternative neither meets the ARARs nor the RAOs because this alternative does not reduce the toxicity, mobility, or volume of impacted soil. Additionally, the risks to human health and the environment, including plants and burrowing mammals, at Site FTIR-40 Area 1.1 would not be reduced. The 5-year present-value of the no-action alternative is $7,000 (Table P-4).
- Alternative 2 - Institutional Controls - As with the no-action alternative, this alternative does not reduce the toxicity, mobility, or volume of the contaminants in the soil. However, this alternative relies on control measures to prevent access or exposure to contaminated areas at the site. By implementing access and land use restrictions, this alternative would improve protection of human health under the current and future land use scenarios. Potential adverse impacts to ecological receptors, though, will remain. Although this option would comply with the intent of most ARARs, it does not achieve the RAOs. Cooperation from between the

Army and the appropriate regulatory agencies would be required to enact the access and land use restrictions. The 5-year present worth of the institutional controls alternative is $108,000 (Table P-5).

- Alternative 3 - Surface Debris Removal with Institutional Controls - This alternative would reduce the potential of injury resulting from contact with surface debris and improve the aesthetics of the site. However, this alternative does not achieve any of the RAOs and is only slightly more effective than Alternative 2 due to an improvement in aesthetics and habitat protection and a minimal reduction in the volume and toxicity of soil contaminants at the site. There is a short-term hazard to construction workers during implementation of this alternative because potential UXO would need to be located and removed. The 5-year present-value of this alternative is $152,000 (Table P-6).

- Alternative 4 - Limited Soil Removal to 3.5 feet and Backfill with Imported Soil- This alternative will remove the first 3.5 feet of debris and impacted soils. Potential risks to human health and ecological receptors will be reduced to acceptable levels because 3.5 feet is the maximum burrowing depth of the Mojave ground squirrel. Alternative 4 would provide improvements in long-term soil, air, groundwater, and surface water qualities. There will be a short-term hazard to construction personnel working at the site during excavation activities. Following the implementation of this alternative, some erosion and drainage control maintenance activities and land use restrictions would be required. This alternative meets the intent of ARARs and the RAOs. The 5-year present-value of this alternative is $488,000 (Table P-7).

- Alternative 5 - Clean Closure - Soils impacted with municipal waste and lead and copper above the cleanup levels will be removed from Site FTIR-40 Area 1.1. By reducing the volume and toxicity of COCs and COECs at this site, the potential risks to human health and ecological receptors would be reduced. This alternative would be more effective than Alternative 4 by improving long-term soil, air, groundwater, and surface water qualities. Short-term hazards to construction personnel working at the site during excavation activities would be the same as described for Alternative 4. Unlike Alternative 4, no long-term maintenance would be required and would not require land use restrictions. This alternative meets the intent of all ARARs and the RAOs. Conventional equipment can be used to excavate the soil. Transportation of soils and disposal at a RCRA facility is easily implementable. The 5-year present-value of this alternative is $902,802 (Table P-8).

In conducting the detailed analysis of alternatives, the expected performances of the five alternatives described in Section 10.4 for the Site FTIR-40 Area 1.1 waste pile are comparatively evaluated against the nine evaluation criteria. The detailed analysis of alternatives for Site FTIR-40 Area 1.1 is summarized in Table 11-2.

11.3.1 Overall Protection of Human Health and the Environment

As discussed in the HHRA presented in Section 6.0, lead was identified as a COC in Site FTIR-40 Area 1.1 surface soils The 99th percentile blood-lead estimate for industrial workers (i.e., 77 μg/dl) would exceed the acceptable blood-lead criterion of 10 μg/dl. In addition, copper and lead were identified as COECs for small mammals, specifically the Mojave ground squirrel, in the Phase II Ecological Validation Study presented in Section 7.0. For copper and lead, the residual ecological HQ estimates would be 1.1 and 9, respectively. Therefore, Alternative 1, No Action, would not achieve RAOs or SSCLs.

Alternative 2, Institutional Controls, provides the minimum action necessary to improve the protection of human health by reducing the potential for direct contact with soil impacted with metals through land use restrictions and restricted access. The 99th percentile blood-lead estimate for industrial workers would be less than the acceptable blood-lead criterion of 10 ug/dl, as a result of decreased exposure. Although Alternative 2, Institutional Controls, would achieve acceptable human health risk levels, it does not protect ecological receptors beyond Alternative 1. Residual ecological HQ estimates for copper and lead would remain 1.1 and 9, respectively. Therefore, Alternative 2, No Action, would not achieve ecological RAOs or SSCLs

Alternative 3, Surface Debris Removal with Institutional Controls, same as Alternative 2 however, includes the removal of surface debris from the site. The removal of surface debris does not provide significant protection to human health, ecological receptors, or the environment; however, it does improve the aesthetics of the site. The 99th percentile blood-lead estimate for industrial workers would be less than the acceptable blood-lead criterion of 10 ug/dl, as a result of decreased exposure. Residual ecological HQ estimates for copper and lead would continue to be 1.1 and 9, respectively. Therefore, Alternative 3, No Action, would not achieve ecological RAOs or SSCLs.

Alternative 4, Limited Soil Removal to 3.5 Feet and Backfill with Imported Soil, is considered more protective of human health, ecological receptors and the environment than Alternatives 2 and 3, because direct contact by humans and ecological receptors with lead impacted soil greater than clean up goals is significantly reduced. Soils impacted with metals above the cleanup goals would be excavated to a depth of 3.5 feet below ground surface. The excavated area would be backfilled and compacted with clean imported soil. A depth of 3.5 feet was selected based on the maximum burrow depth of the Mojave ground squirrel of 3.5 feet, as discussed in Section 7.0. The 99th percentile blood-lead estimate for industrial workers (i.e., 3.6 ug/dl) would be less than the acceptable blood-lead criterion of 10 ug/dl. Achievement of SSCLs would be associated with residual HQ estimates for copper and lead of approximately 1.0 and 0.9, respectively. Since waste and soils potentially impacted with lead and copper remain in the soil, Alternative 4 includes access and land use restrictions.

Alternative 5, Clean Closure, provides the same human health and ecological protection as Alternative 4, but is considered more protective of the environment because all impacted soil and waste material below 3.5 feet bgs is removed. The 99th percentile blood-lead estimate for industrial workers (i.e., 3.6 ug/dl) would be less than the acceptable blood-lead criterion of 10 ug/dl. Achievement of SSCLs would be associated with residual ecological HQ estimates for copper and lead of approximately 1.0 and 0.9, respectively. The excavation will be backfilled, compacted, and restored to native conditions.

11.3.2 Compliance with ARARs

Alternative 1, No Action, does not comply with ARARs and RAOs. Alternative 2, Institutional Controls, complies with and meets the intent of most ARARs; however, institutional controls does not achieve RAOs. Alternative 3, Surface Debris Removal with Institutional Controls, complies with and meets the intent of most ARARs; however, Alternative 3 does not achieve RAOs. Alternative 4, Limited Soil Removal to 3.5 Feet and Backfill with Imported Soil, meets the intent of ARARs and achieves RAOs and SSCLs by excavating and removing the first 3.5 feet of waste material and impacted soil and replacing the excavated soil with clean imported soil. Alternative 5, Clean Closure, meets intent of ARARs and achieves RAOs and SSCLs. Alternative 5 includes excavating and removing all of the waste material and metal impacted soil and replacing the excavated soil with clean imported backfill material.

11.3.3 Long-Term Effectiveness

Alternative 1 does not satisfy the RAOs because the impacted soil volume remains unchanged. Alternative 2 satisfies the RAOs under the current land use scenario but does not satisfy the RAOs for preventing direct contact with soil impacted with metals. Alternative 3 satisfies the RAOs under the current land use scenario but does not satisfy the RAOs for preventing direct contact with soil impacted with metals. Alternative 4 satisfies the RAOs for current industrial land use scenarios. However, Alternative 4 requires five-year site reviews, maintenance, and land use restrictions. Alternative 5 satisfies all of the RAOs for both the current and unlimited future land use scenarios. No long-term maintenance is required.

11.3.4 Reduction of Toxicity, Mobility, and Volume

Alternatives 1, 2, and 3 do not actively reduce the TMV of contaminated soils and debris. However, the mobility of COECs and the toxicity of the soil at Site FTIR-40 Area 1.1 are considered to be minimal as discussed in Section 5.0. Alternatives 4 and 5 reduces impacted soil volume and air borne lead particulate matter by removing the source of contamination.

11.3.5 Short-Term Effectiveness

Alternatives 1 and 2 are not expected to adversely impact human health and the environment during implementation. Alternative 3 would present some potential short-term hazard to remediation workers would exist during implementation of Alternatives 3, 4, and 5 due to the potential to encounter UXO UXO avoidance using trained professionals is included in all alternatives that require intrusive activities to limit the construction hazards. In addition, Alternatives 4 and 5 pose additional hazards associated with operation of heavy equipment, working around open excavations, and inhalation of air borne lead particulate matter.

Implementation of Alternatives 4 and 5 would temporarily impact the environment by modifying the native conditions at the site. Revegetating the site with quick-growing grasses would mitigate some of the impact until natural vegetation can return.

11.3.6 Implementability

Alternatives 1 and 2 are easily implemented at Site FTIR-40 Area 1.1. Alternatives 3, 4, and 5 are slightly more difficult to implement because they require earth-moving equipment with explosion shields and dedicated UXO avoidance crews on site during all intrusive activities. Simple excavating activities are expected to take up to 2 times as long under these conditions.

11.3.7 Cost

Cost estimates for each of the five alternatives are presented in Tables P-4 through P-8 (Appendix P). These tables provide a detailed list of the components included in the cost estimates. These costs are summarized in Table 11-2.

In general, the estimated present value increases from Alternative 1 to Alternative 5 due to successive additions of component technologies. Alternative 1 is estimated to cost $7,000, Alternative 2 is estimated to cost $108,000, Alternative 3 is estimated to cost $152,000, Alternative 4 is estimated to cost $702,893 and Alternative 5 is estimated to cost $1,264,000.

11.3.8 State and Community Acceptance

The no action alternative would likely be acceptable to the public because of the remote location of Site FTIR-40 Area 1.1. The state may request involvement in land use restrictions.

12.0 REMEDIAL INVESTIGATION /FEASIBILITY STUDY RECOMMENDATIONS

This section presents recommendations for Sites FTIR-38 and FTIR-40 based on the results of the RI/FS. The remedy selected for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 are based on the findings of the RI (Section 1.0 through 5.0), the HHRA (Section 6.0), the Phase II Validation Study (Section 7.0), and the FS (Sections 9.0 through 11.0). A summary of RI/FS recommendations is provided in Table 12-1.

12.1 REMEDIAL INVESTIGATION RECOMMENDATIONS

The data collected during the RI for Sites FTIR-38 and FTIR-40 were evaluated to further characterize the nature and extent of soils impacts at each site. The nature and extent of impacts was assessed by a comparison of the soil and plant tissue analytical data with background values, an evaluation of the potential fate and transport of contaminants, and human health and ecological risk assessments. Based on the results of the baseline HHRA and the Phase II Ecological Validation Study, recommendations were made for either no further action or inclusion of the site into the subsequent FS as discussed below. Constituents of concern were identified and RAOs and site-specific cleanup levels were developed for areas that required remedial action.

Sites FTIR-38 Area 1 and FTIR-40 Area 2 were recommended for no further action because the results of risk assessments indicated that contaminants at these sites do not pose an unacceptable risk to human health or the environment. At Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 one COC (lead) and three COECs (aluminum, lead and copper) were identified in the surface soils. The HHRA (Section 7.0) identified lead as a COC in surface soil (0 to 1 foot) in Site FTIR-38 Area 2 and FTIR-40 Area 1.1. The Phase II Validation Study identified aluminum as a COEC in the surface soil (0 to 3.5 feet) based on the Mojave ground squirrel as the primary receptor. The Phase II Validation Study also identified lead and copper as COECs in Site FTIR-40 Area 1.1. Therefore, the RI recommended that Sites FTIR-38 Area 2 and FTIR-40 Area 1.1 be carried forward for analysis of remedial action alternatives for COCs and COECs in the FS.

12.2 FEASIBILITY STUDY RECOMMENDATIONS

The FS considered a wide array of remedial technologies, no action and institutional controls, in developing a remedy for Sites FTIR-38 Area 2 and FTIR-40 Area 1.1. The recommendations are based on the detailed analysis of alternatives (Section 11.0) and other site-specific considerations, including habitat destruction, sensitive and endangered species present future land use, human health and ecological risks, and long-term maintenance. Table 12-1 presents a summary of the recommended remedial alternatives and the rationale used in the selection of the recommended alternatives for each site.

12.2.1 Site FTIR-38 Area 2

Alternative 3, Removal/Disposal of soils exceeding the RAOs and SSCLs, is the preferred alternative for Site FTIR-38 Area 2. Alternative 3, is protective of human health and ecological receptors because direct contact with soil impacted with metals (primarily lead and aluminum) by humans and ecological receptors above RAOs will be excavated and removed from the site. Alternative 3 complies with or meets the intent of all ARARs and achieves RAOs. In addition, Alternative 3 requires minor long-term maintenance and only requires minimal disturbance of existing habitat. Services, equipment and materials are readily available and no administrative difficulties are associated for implementing Alternative 3. Furthermore, Alternative 3 is moderately easy to implement and remediation construction hazards are minimal.

Alternative 1 does not meet the RAOs because it is not protective of human health or ecological receptors. Alternative 2 reduces human health risk potential but is not protective of ecological receptors.

12.2.3 Site FTIR-40 Area 1.1

Alternative 4, Limited Soil Removal to 3.5 Feet and Backfill with Imported Soil, is the preferred alternative for Site FTIR-40 Area 1.1 because it is equally protective of human health and ecological receptors compared to Alternative 5 (Clean Closure) under future and current land use conditions. Alternative 4 complies with or meets the intent of all ARARs and achieves RAOs and will significantly improve long-term soil quality, surface water quality, and air quality. Services, equipment and materials are readily available and no administrative difficulties are associated for implementing Alternative 4. Furthermore, Alternative 4 is moderately easy to implement, remediation construction hazards are minimal, and Alternative 4 is more cost effective than Alternative 5.

Alternative 1 does not meet the intent of ARARs or achieve RAOs because it is not protective of ecological receptors, or the environment. Alternatives 2 and 3 reduce human health risk potential by land use restrictions, but are not protective of ecological receptors.

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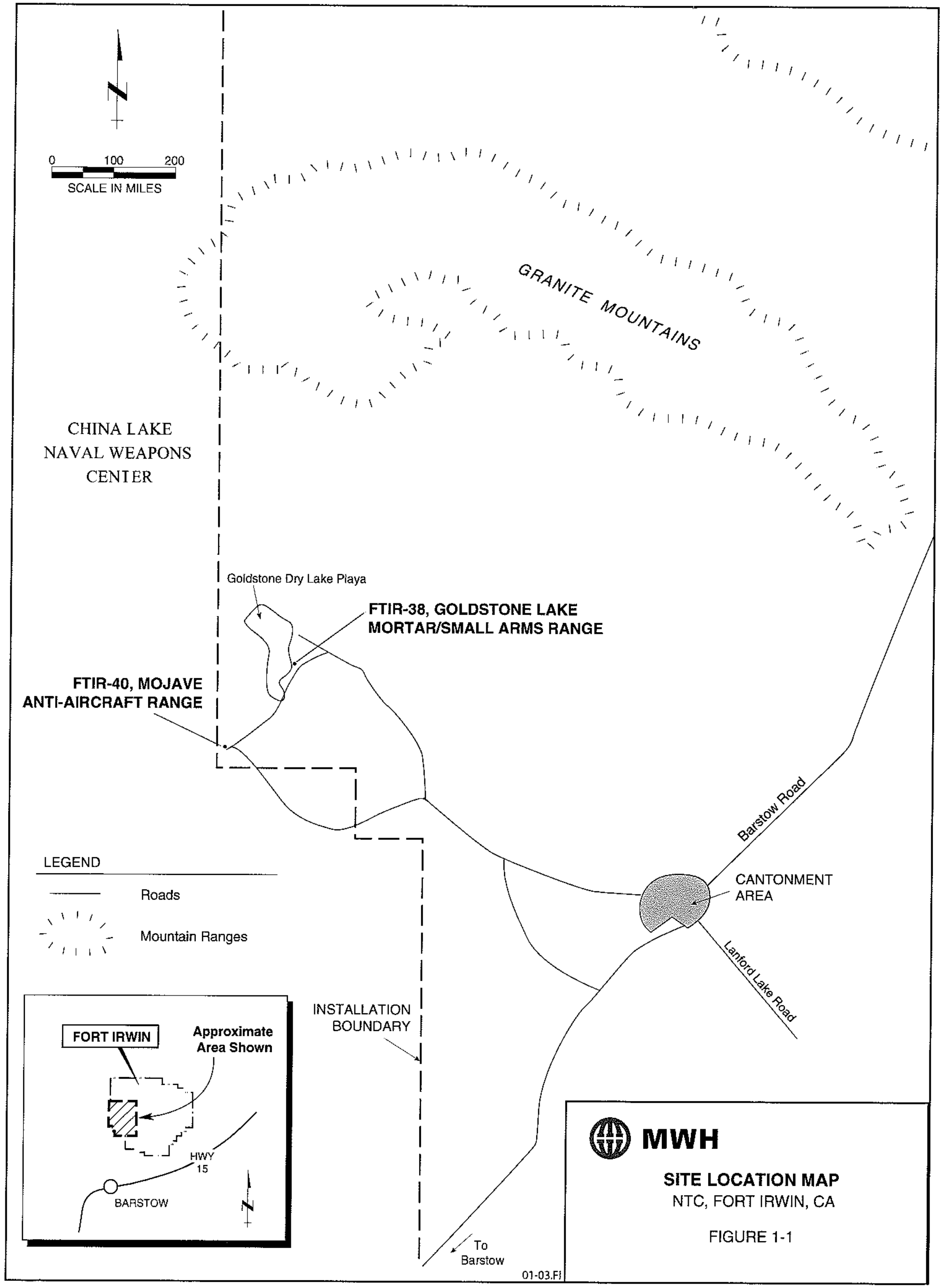

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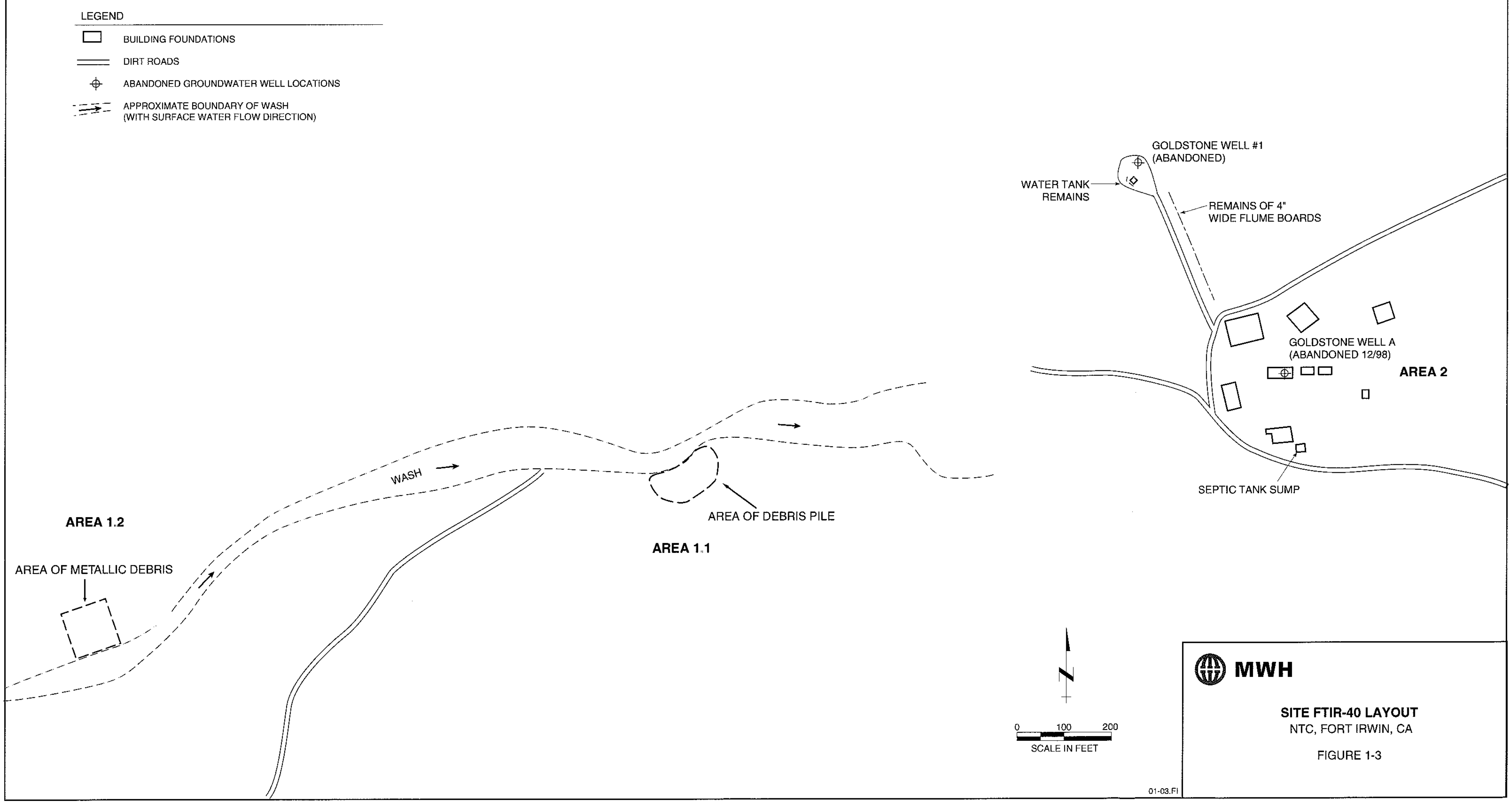
SITE LOCATION MAP

NTC, FORT IRWIN, CA

FIGURE 1-1



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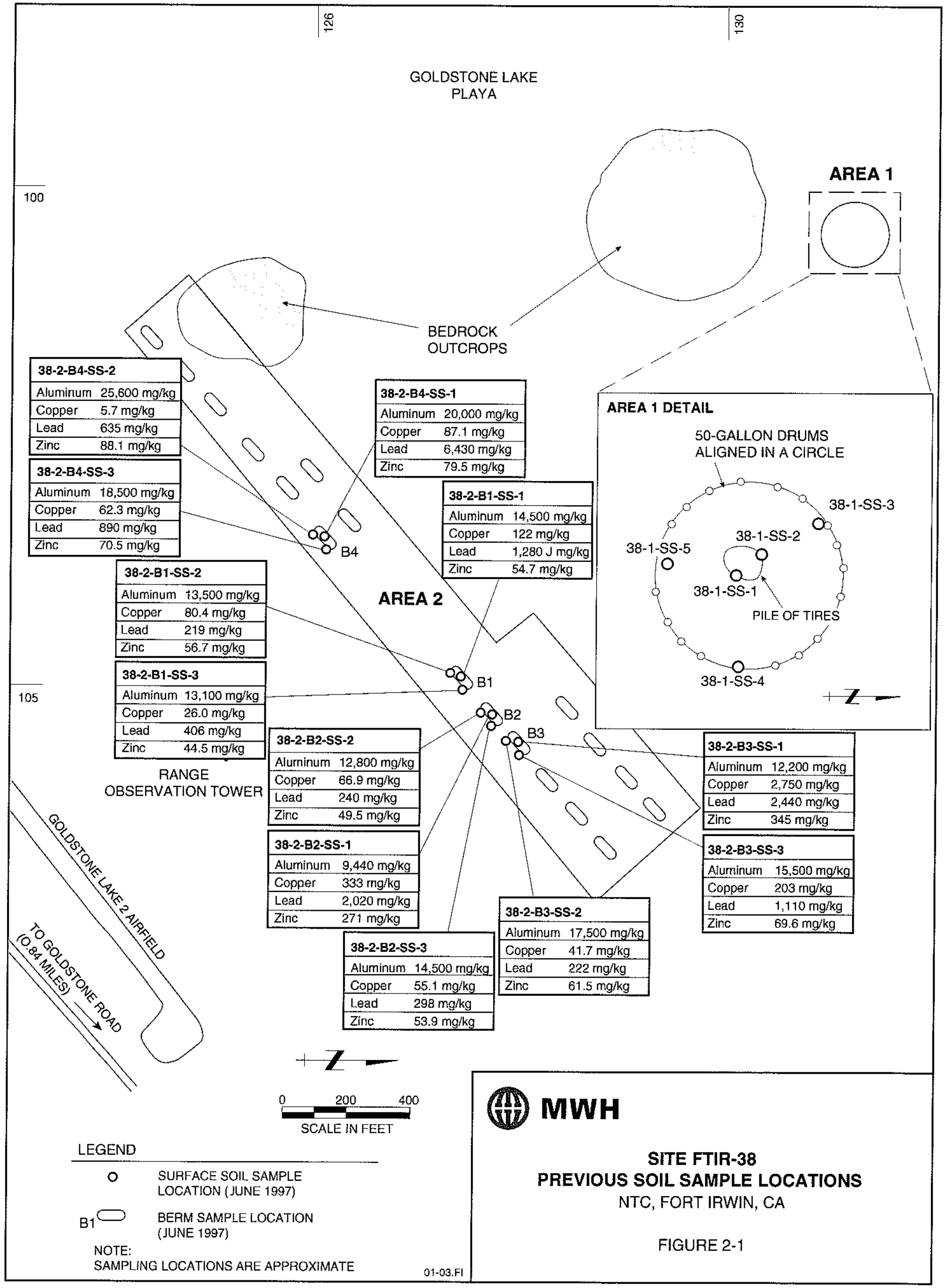
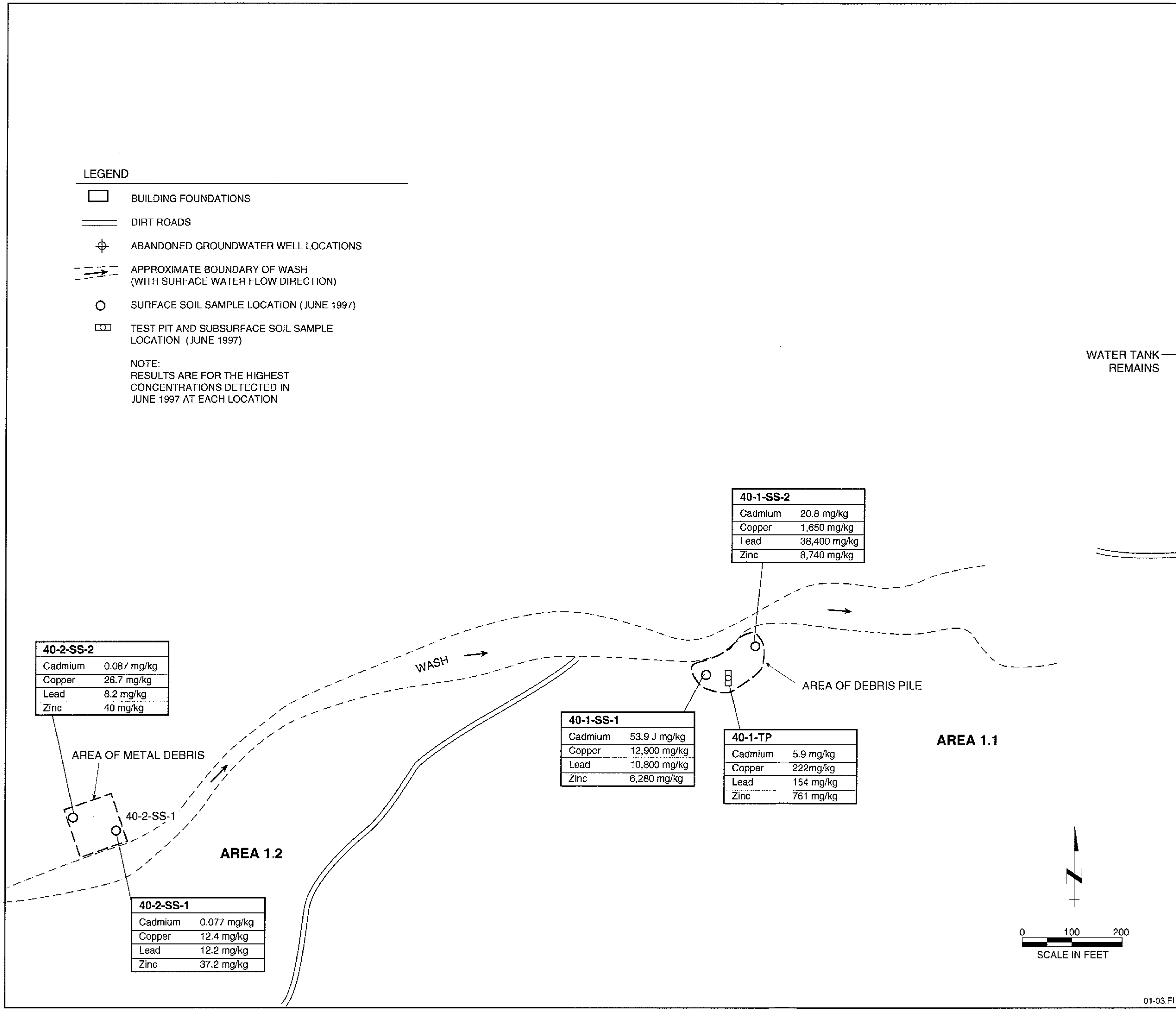
SITE FTIR-40 LAYOUT
NTC, FORT IRWIN, CA

FIGURE 1-3



SITE FTIR-38
PREVIOUS SOIL SAMPLE LOCATIONS
NTC, FORT IRWIN, CA

FIGURE 2-1



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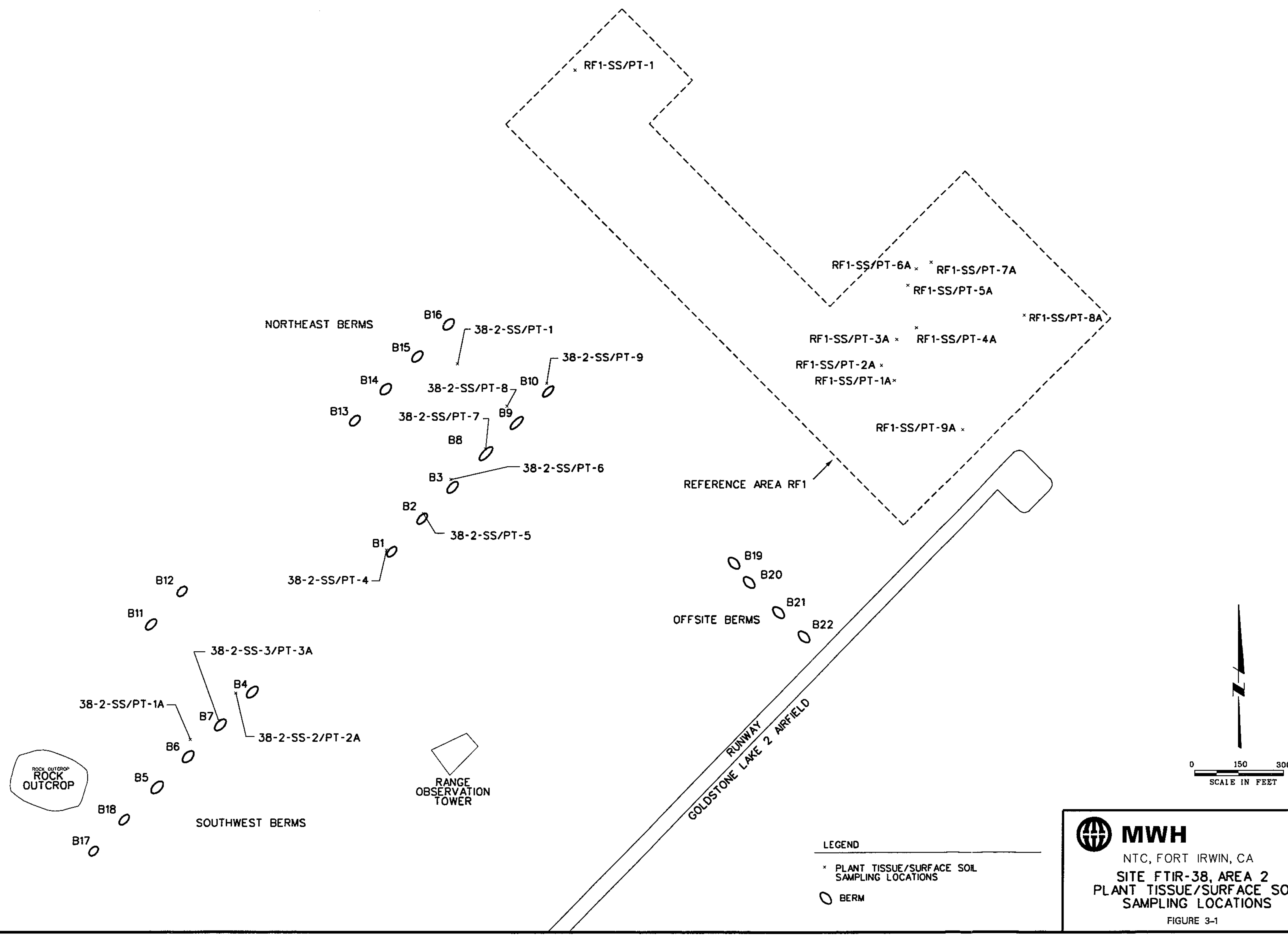
SITE FTIR-40
PREVIOUS TEST TRENCH AND SOIL SAMPLE LOCATIONS
NTC, FORT IRWIN, CA

FIGURE 2-2



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NTC, FORT IRWIN, CA

SITE FTIR-38, AREA 2
PLANT TISSUE/SURFACE SOIL
SAMPLING LOCATIONS

FIGURE 3-1

REFERENCE FILES 1) bsbdr.dgn 2) 3) 4) 5) 6) 7) 8) 9)

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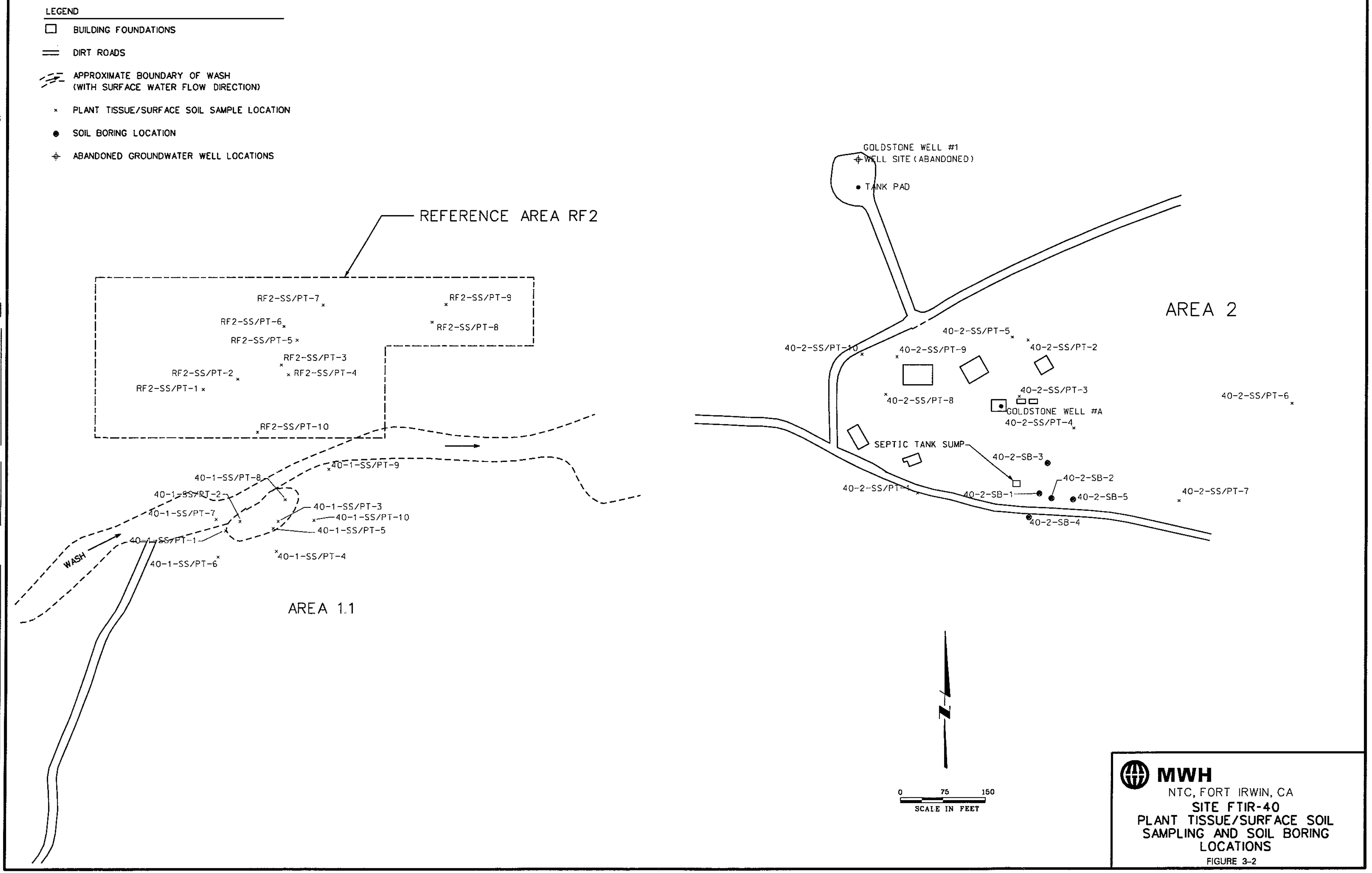

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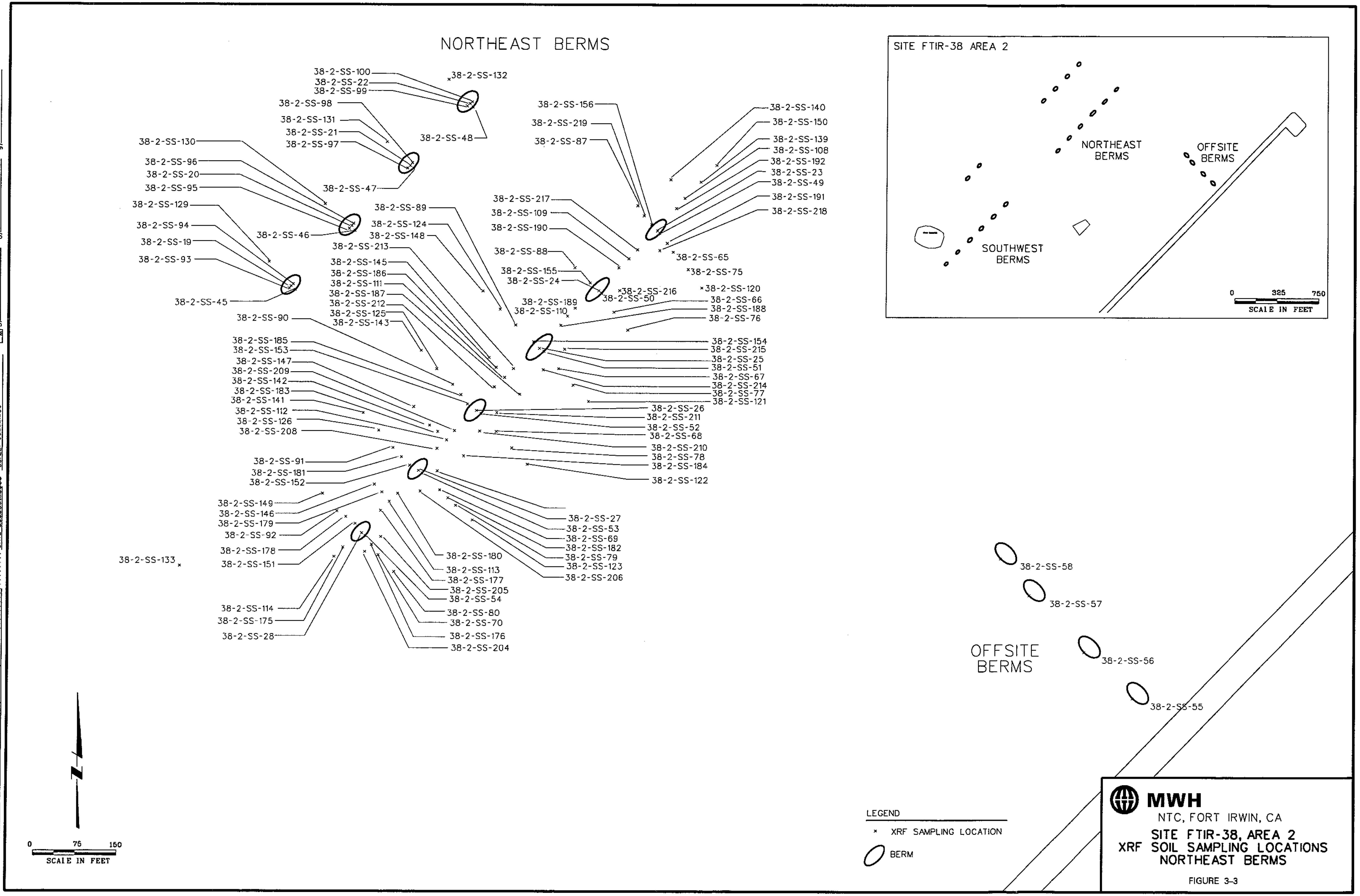
NTC, FORT IRWIN, CA
SITE FTIR-40
PLANT TISSUE/SURFACE SOIL SAMPLING AND SOIL BORING LOCATIONS
FIGURE 3-2



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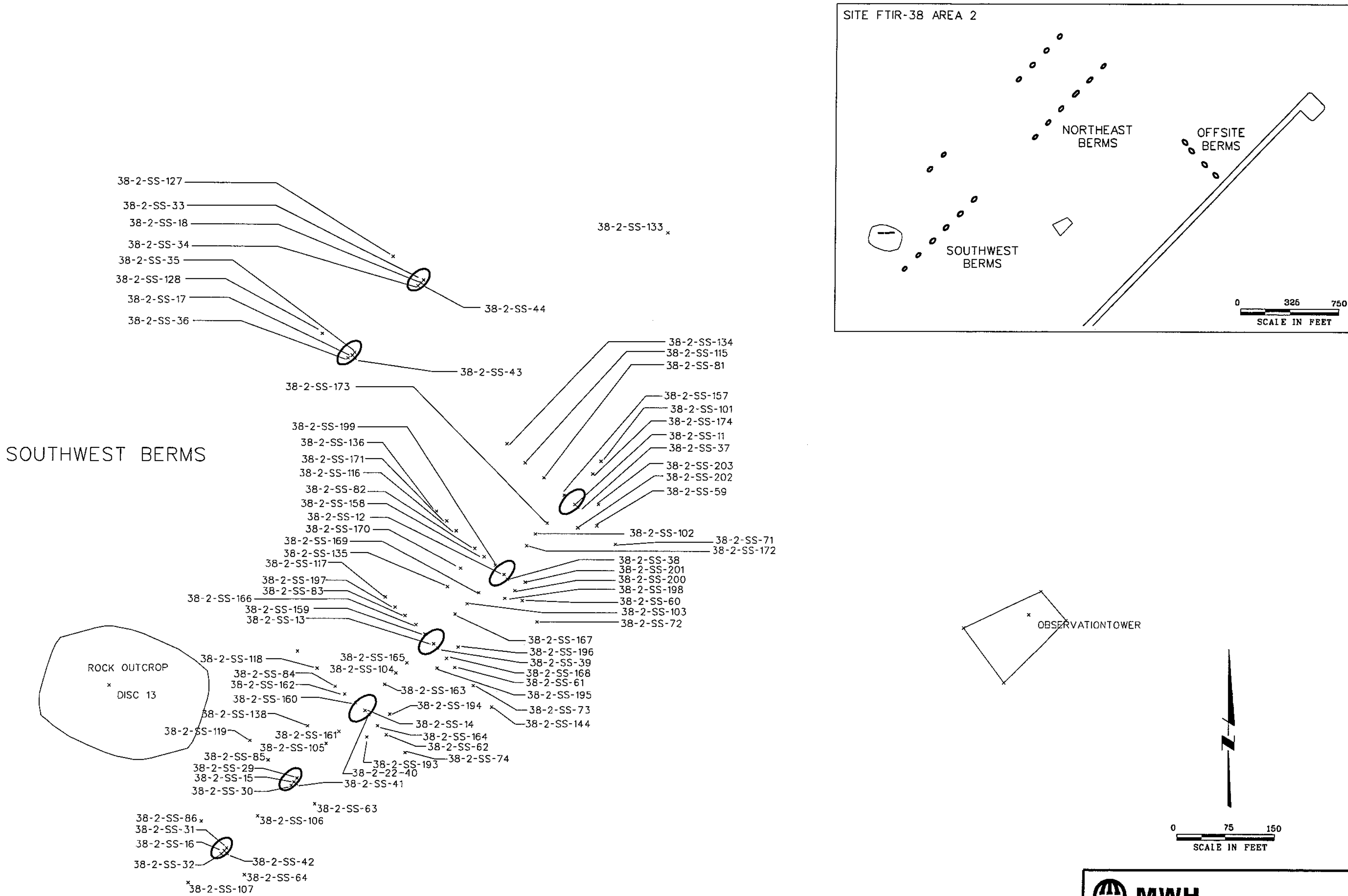
NTC, FORT IRWIN, CA
SITE FTIR-38, AREA 2
XRF SOIL SAMPLING LOCATIONS
NORTHEAST BERMS

FIGURE 3-3



LEGEND

× XRF SAMPLING LOCATION

BERM

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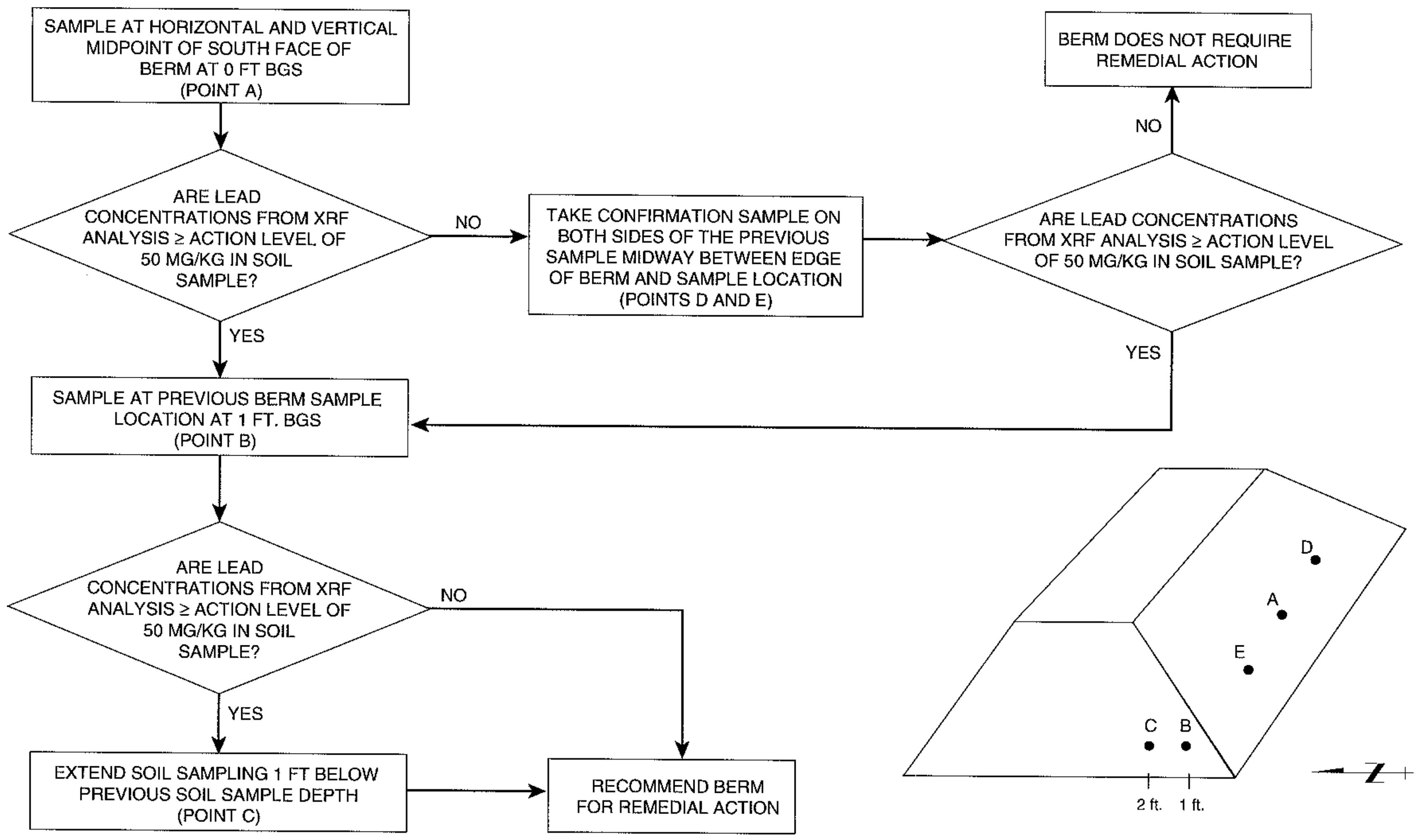
NTC, FORT IRWIN, CA

SITE FTIR-38, AREA 2
XRF SOIL SAMPLING LOCATIONS
SOUTHWEST BERMS

FIGURE 3-4



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SITE FTIR-38 AREA 2
BERM SOIL SAMPLING FLOW CHART
NTC, FORT IRWIN, CA

FIGURE 3-5

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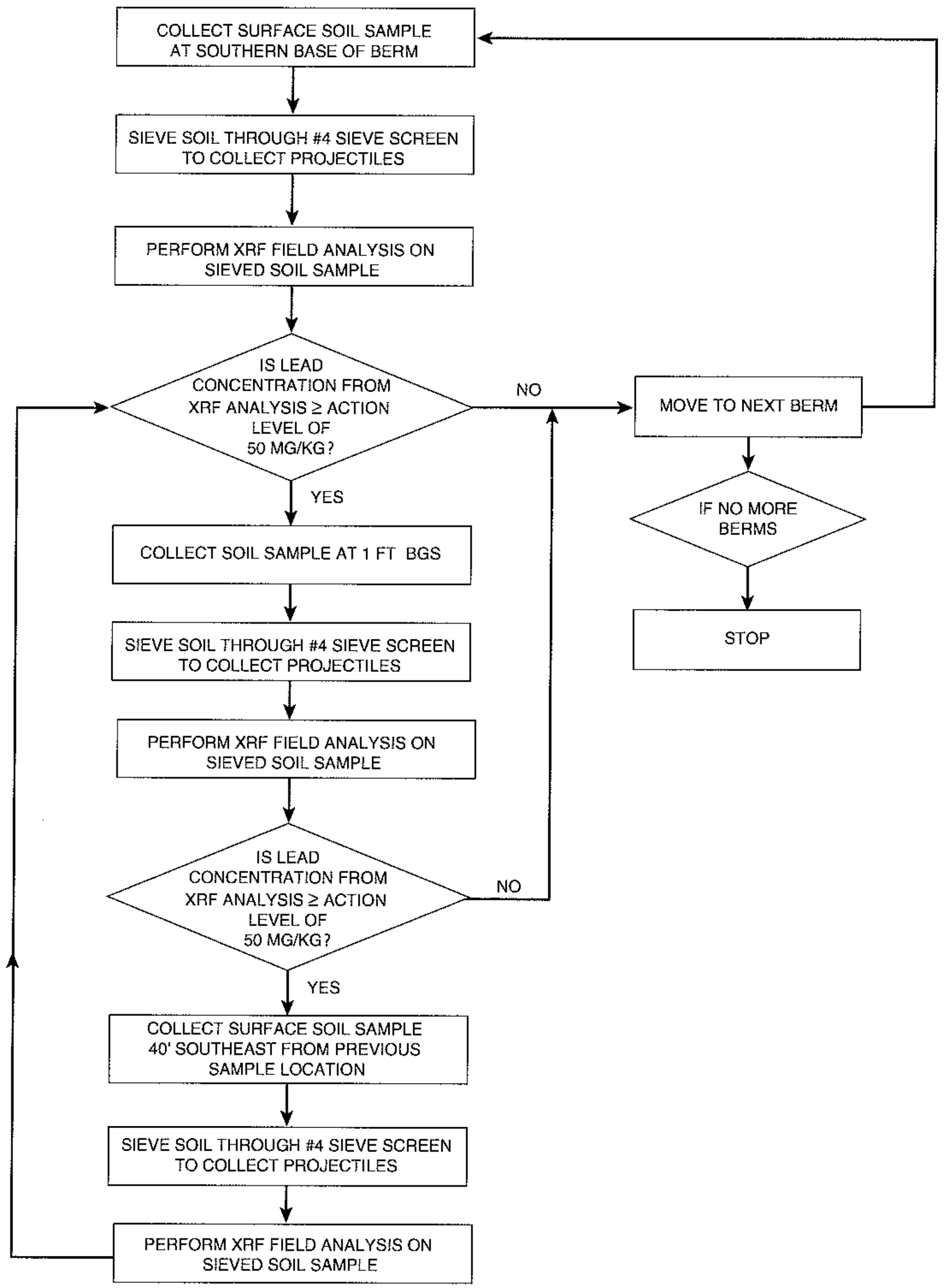

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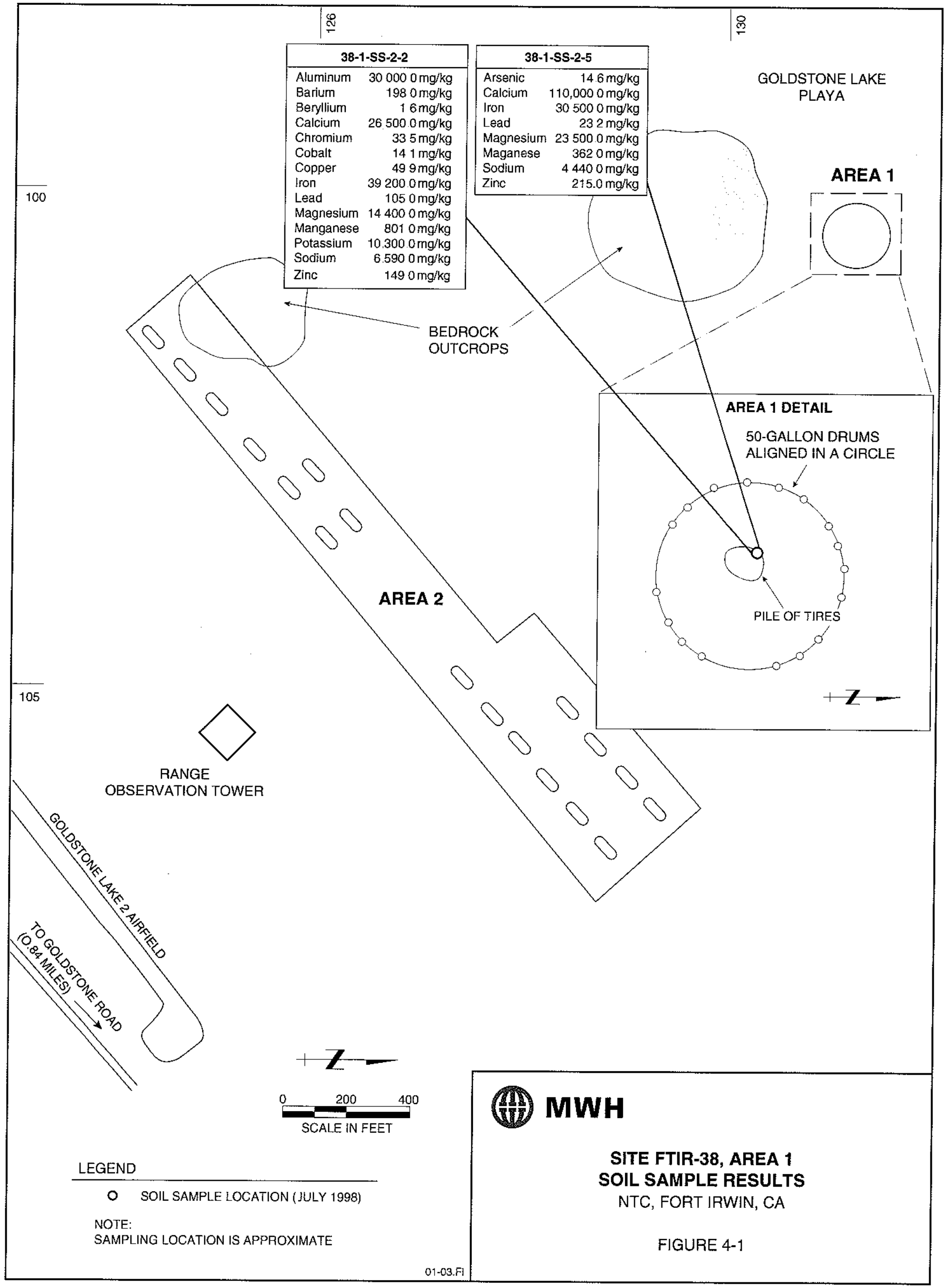
SITE FTIR-38 AREA 2
SAMPLING OF SOIL AROUND BERMS
FLOW CHART
NTC, FORT IRWIN, CA

FIGURE 3-6



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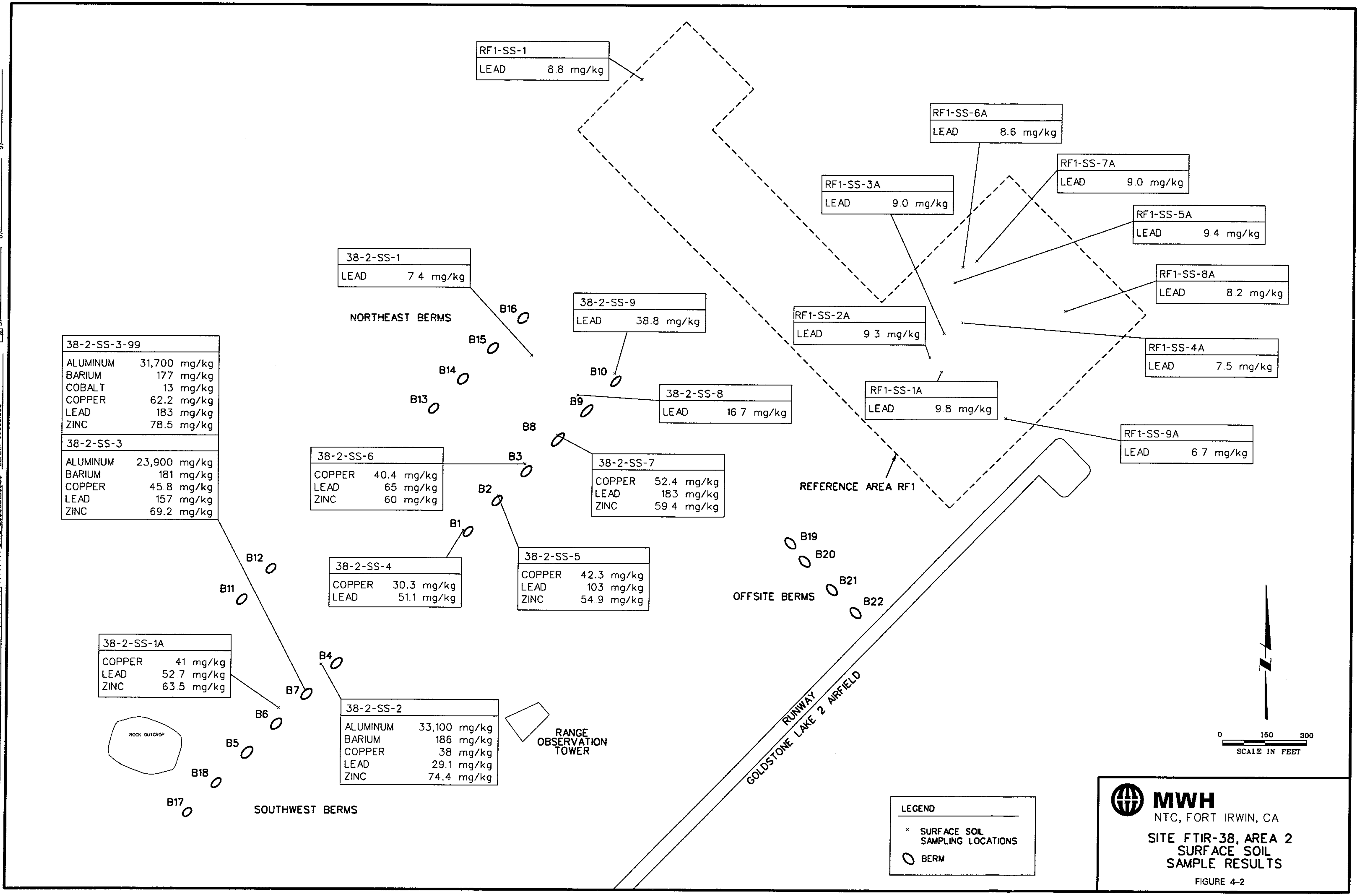
SITE FTIR-38, AREA 1
SOIL SAMPLE RESULTS
NTC, FORT IRWIN, CA

FIGURE 4-1



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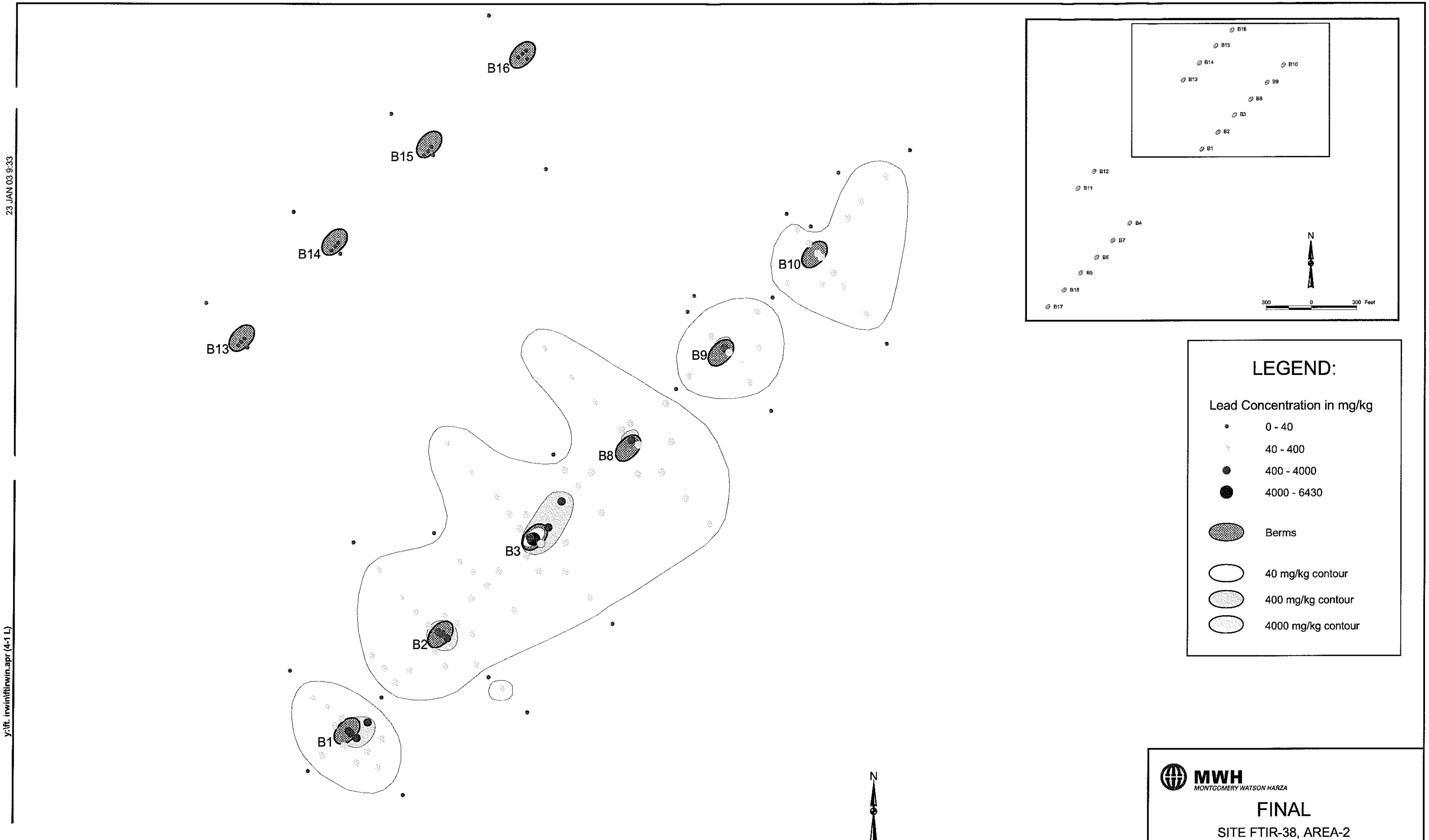

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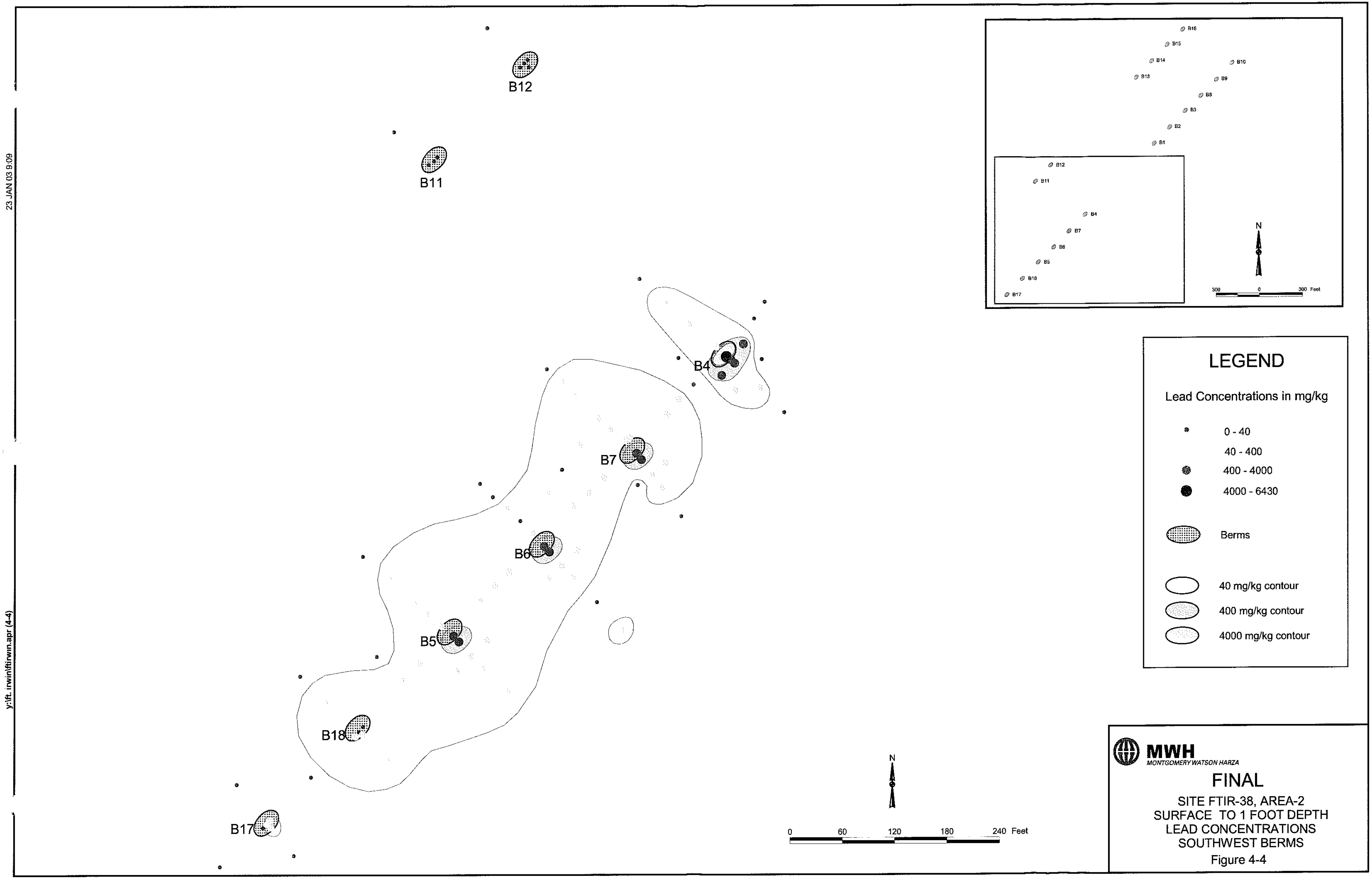
MONTGOMERY WATSON HARZA

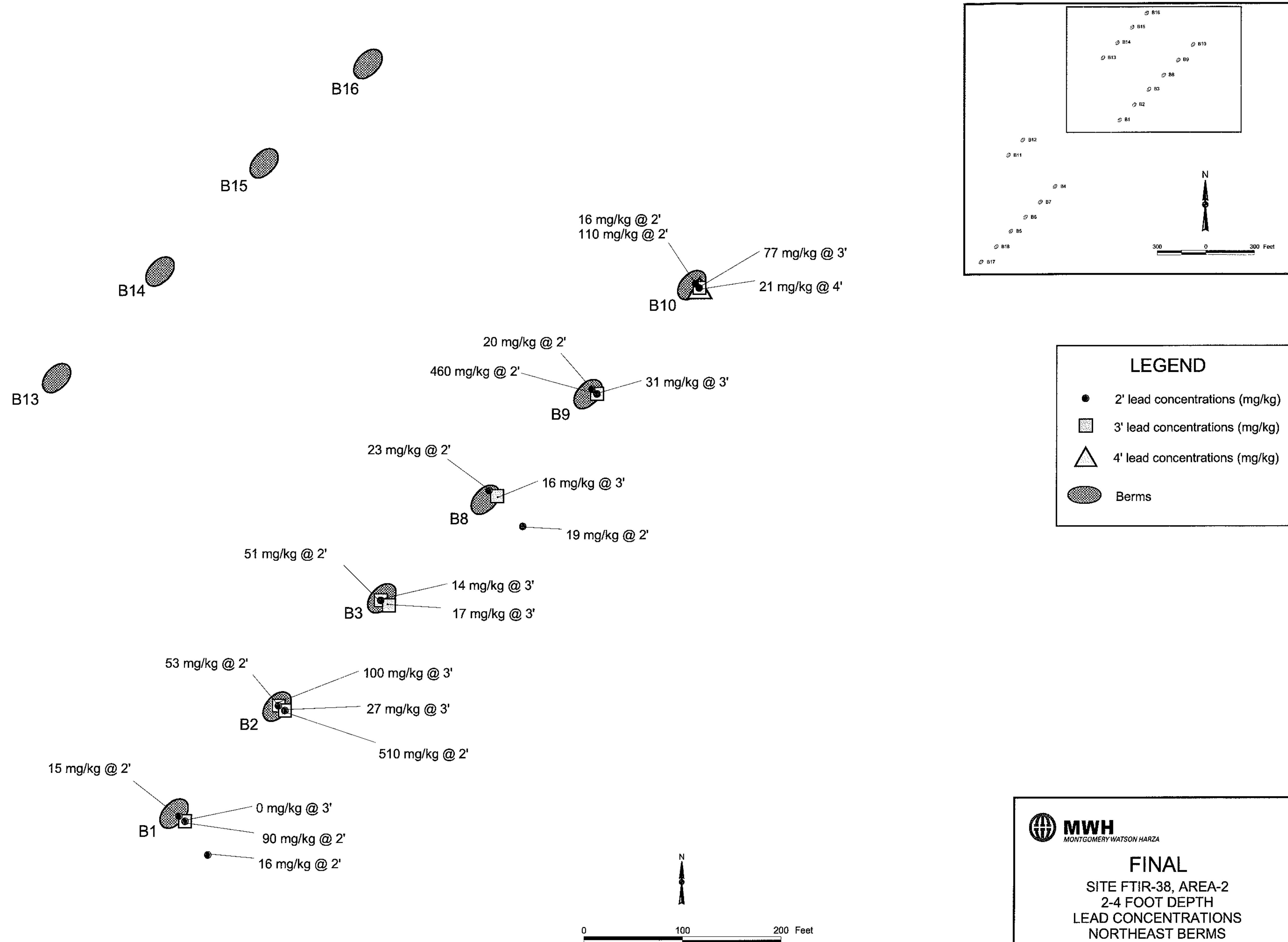
FINAL

SITE FTIR-38, AREA-2
SURFACE TO 1 FOOT DEPTH
LEAD CONCENTRATIONS
NORTHEAST BERMS

FIGURE 4-3



FINAL
SITE FTIR-38, AREA-2
SURFACE TO 1 FOOT DEPTH
LEAD CONCENTRATIONS
SOUTHWEST BERMS
Figure 4-4



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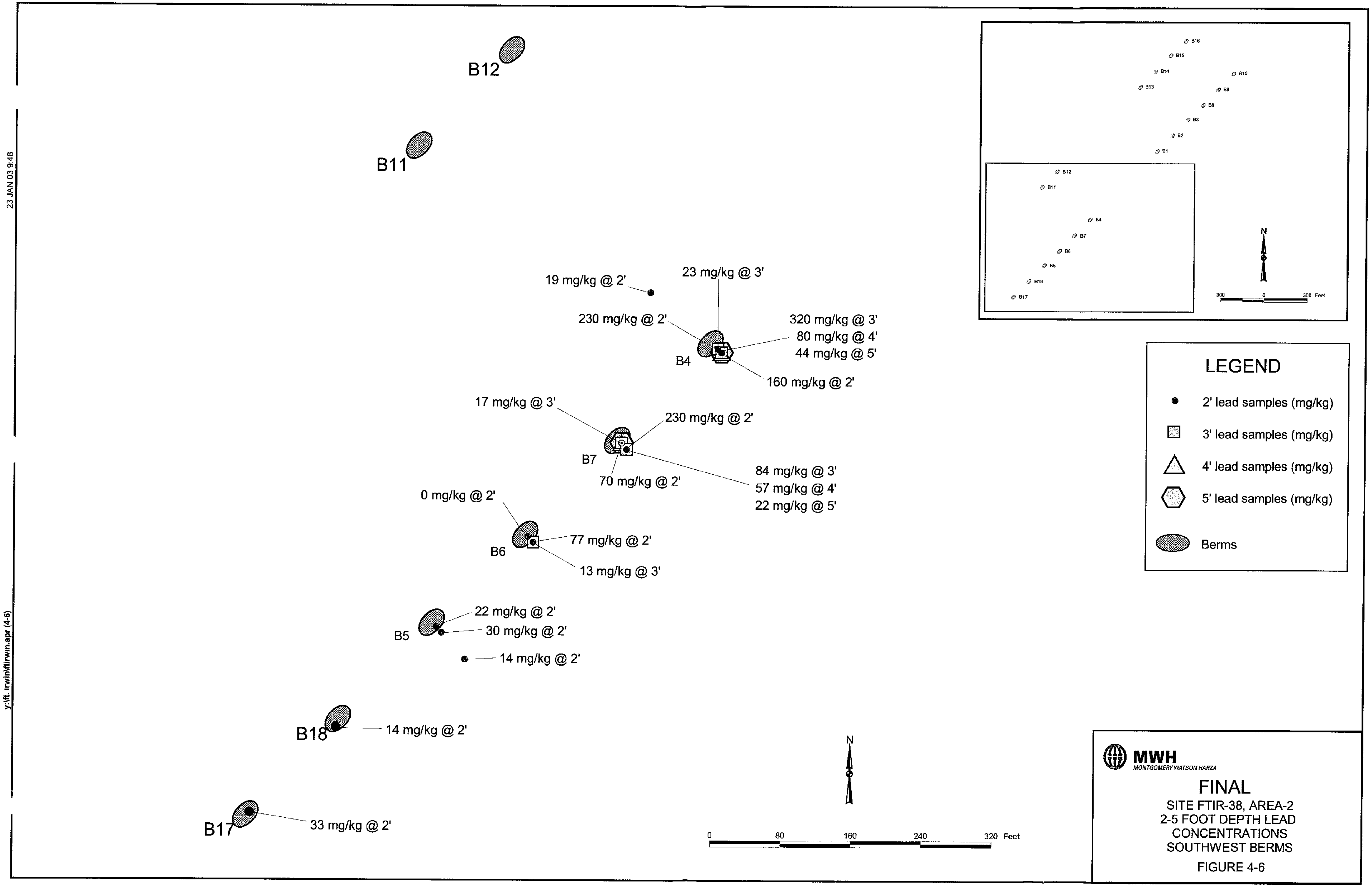
FINAL

SITE FTIR-38, AREA-2
2-4 FOOT DEPTH
LEAD CONCENTRATIONS
NORTHEAST BERMS

FIGURE 4-5



FINAL
SITE FTIR-38, AREA-2
2-5 FOOT DEPTH LEAD CONCENTRATIONS
SOUTHWEST BERMS

FIGURE 4-6

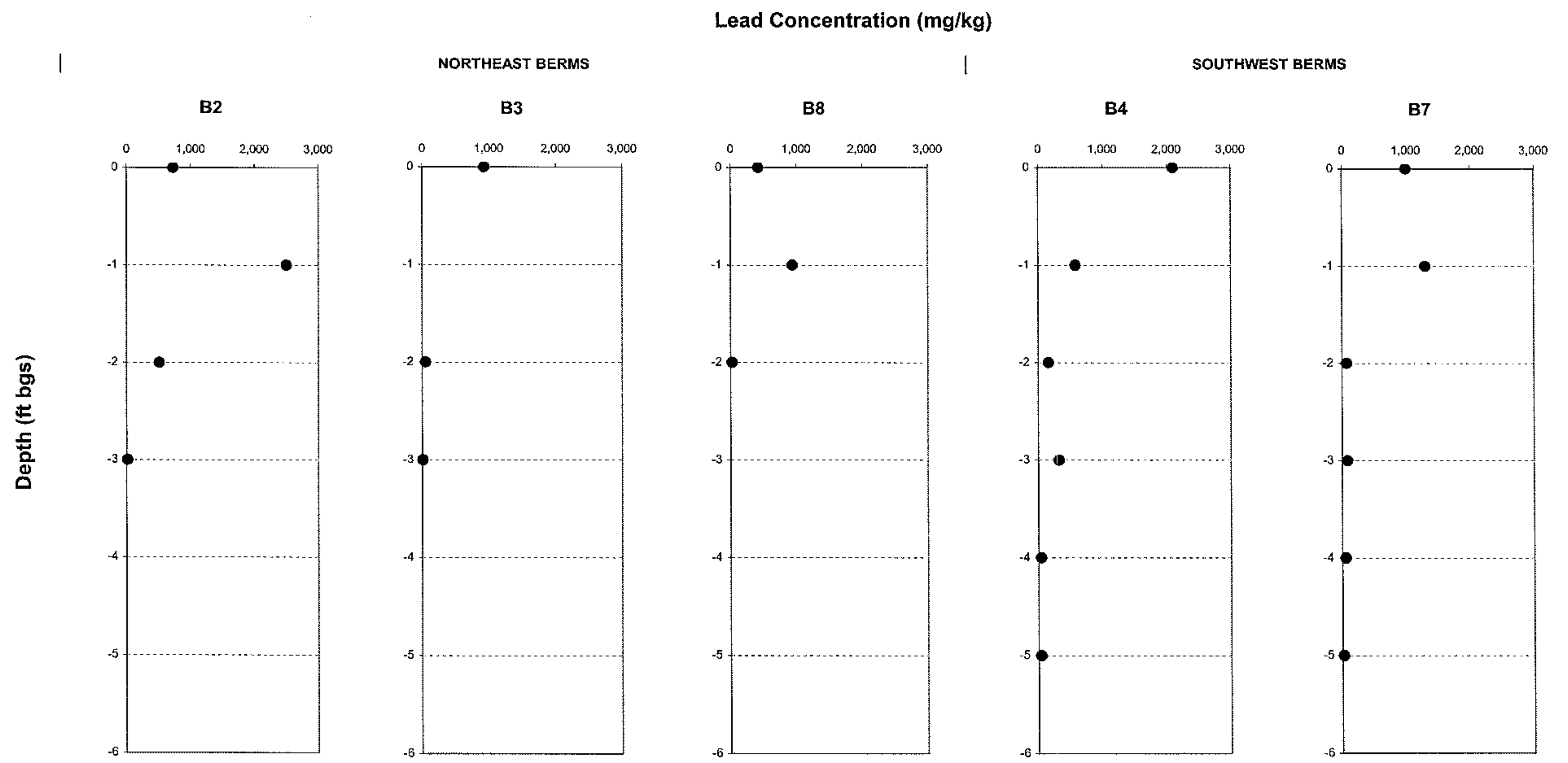


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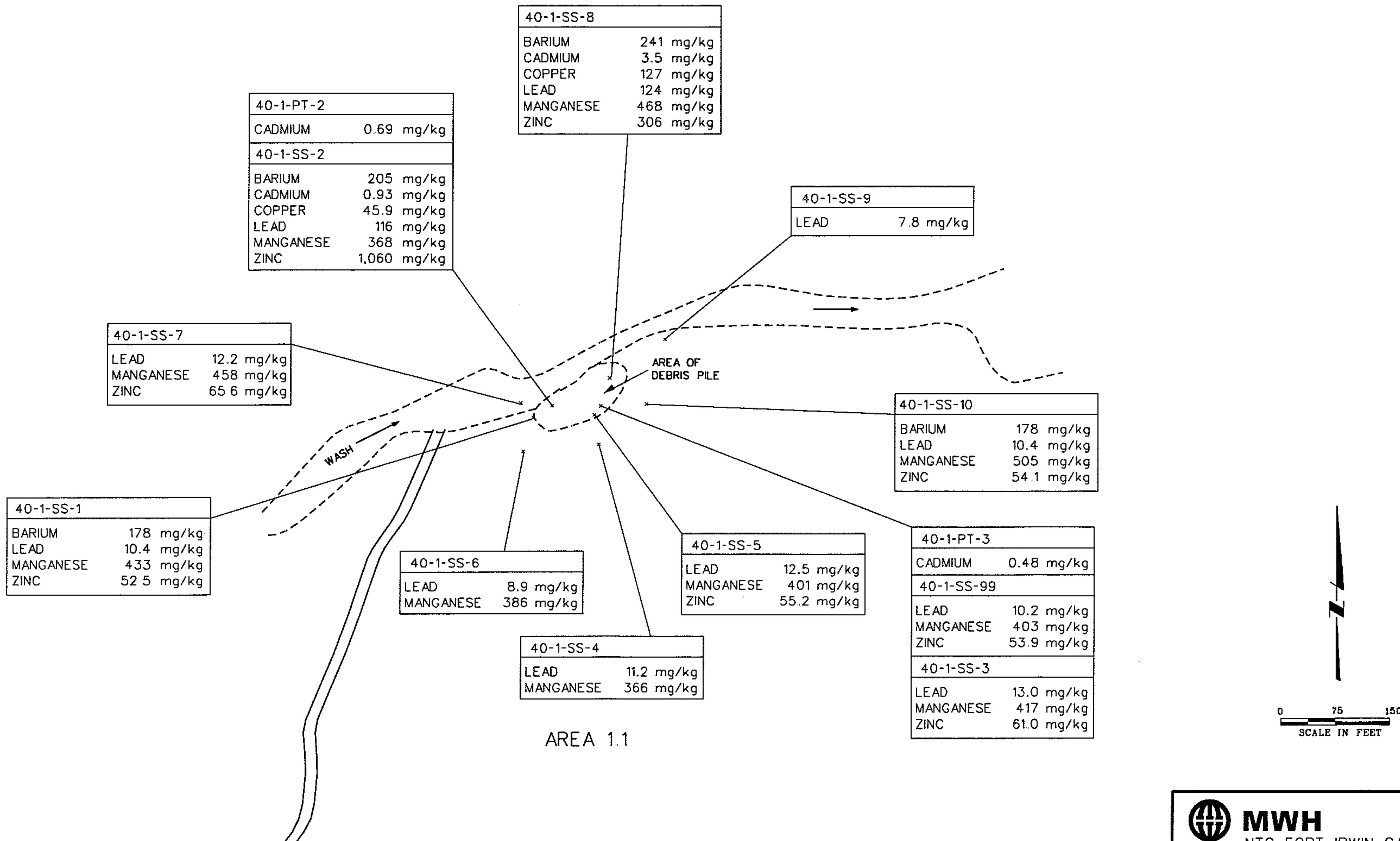
Figure 4-7
SITE FTIR-38 AREA 2
VERTICAL PROFILE OF LEAD
CONCENTRATION WITH SOIL DEPTH

LEGEND

APPROXIMATE BOUNDARY OF WASH (WITH SURFACE WATER FLOW DIRECTION)

× PLANT TISSUE/SURFACE SOIL SAMPLE LOCATION



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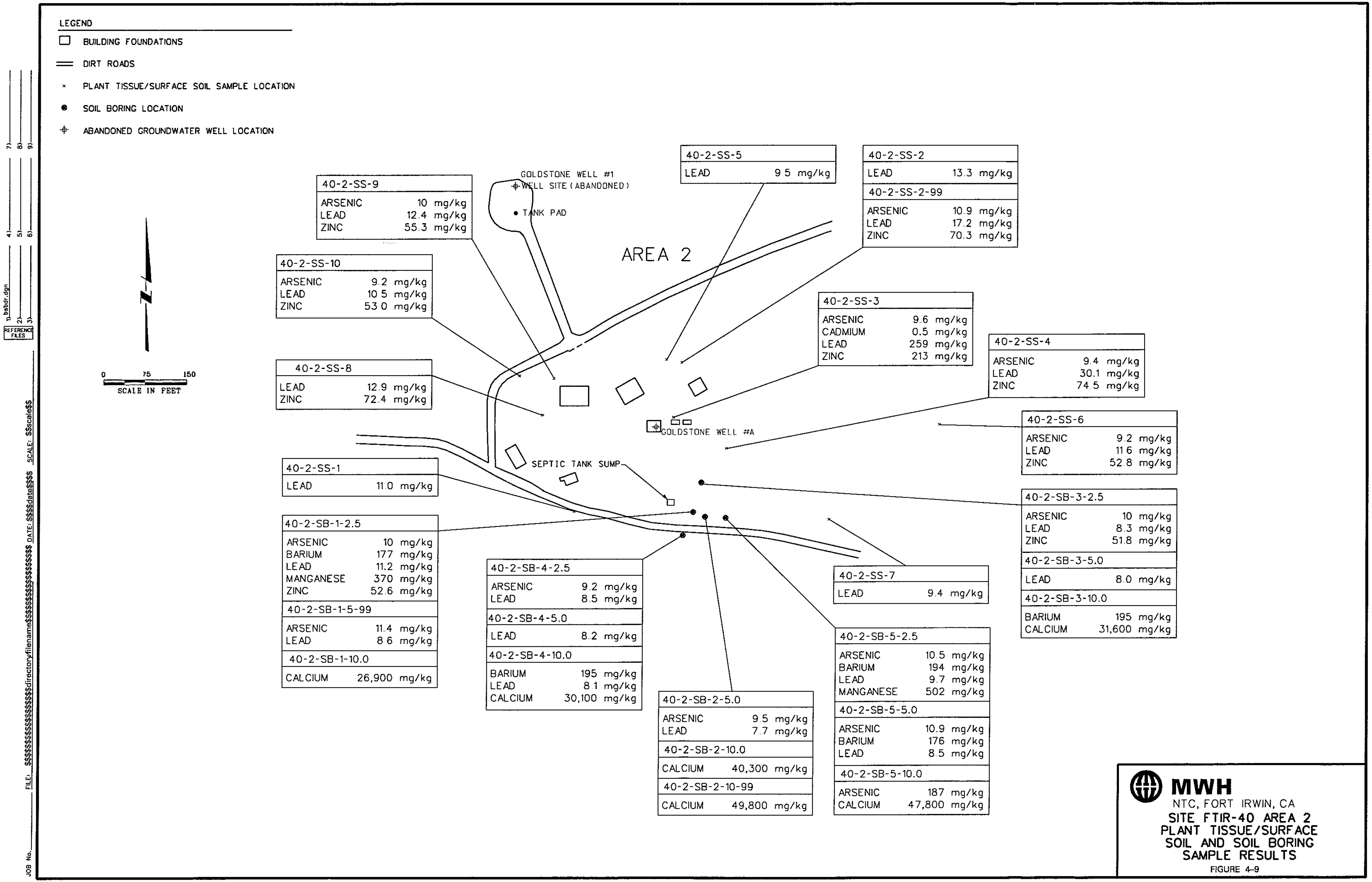
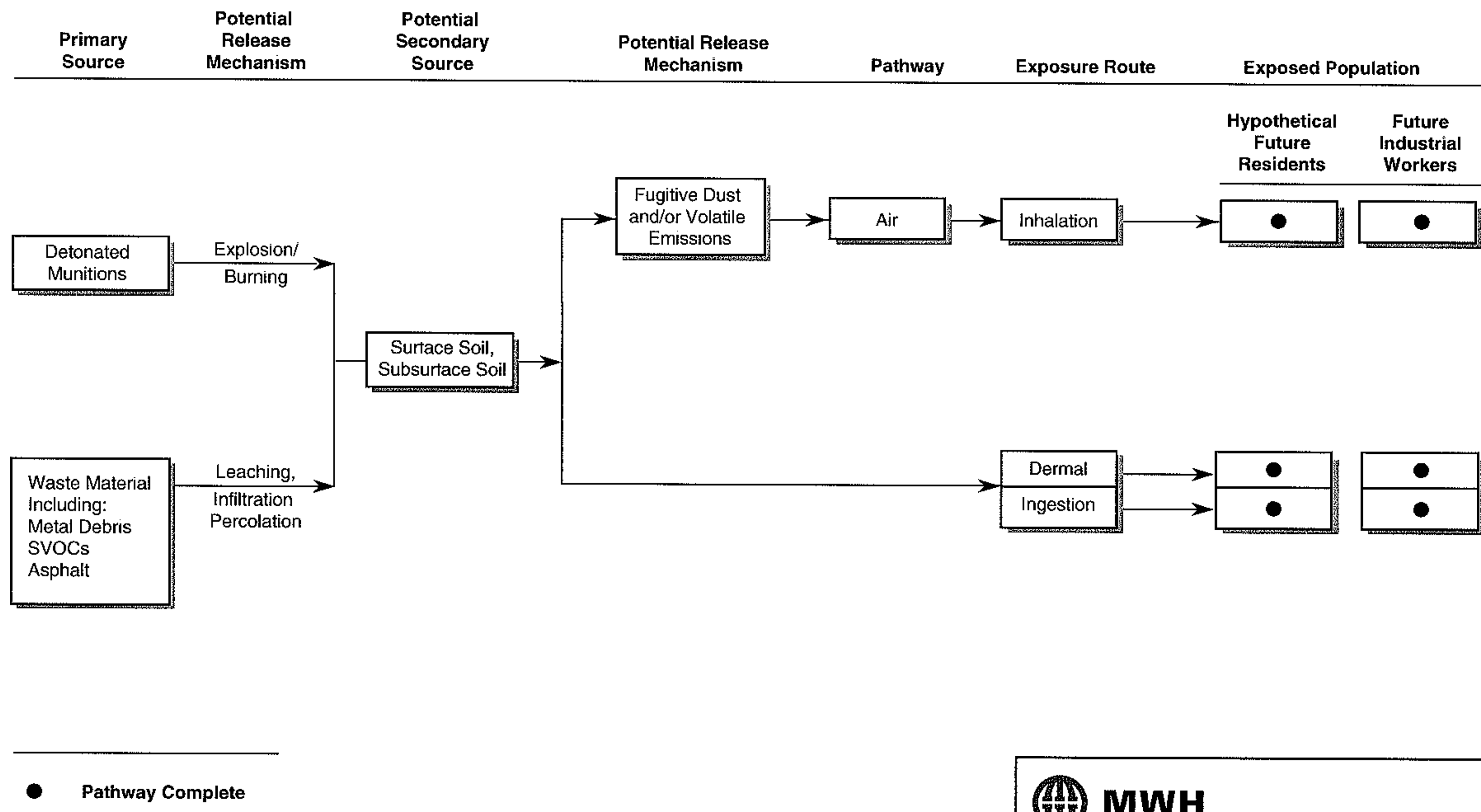
SITE FTIR-40 AREA 1.1
PLANT TISSUE/SURFACE SOIL
AND SOIL BORING SAMPLE RESULTS

FIGURE 4-8


LEGEND
BUILDING FOUNDATIONS
DIRT ROADS
PLANT TISSUE/SURFACE SOIL SAMPLE LOCATION
SOIL BORING LOCATION
ABANDONED GROUNDWATER WELL LOCATION
0 75 150
SCALE IN FEET
N
AREA 2
GOLDSTONE WELL #1
WELL SITE (ABANDONED)
TANK PAD
GOLDSTONE WELL #A
SEPTIC TANK SUMP
40-2-SS-9
ARSENIC 10 mg/kg
LEAD 12.4 mg/kg
ZINC 55.3 mg/kg
40-2-SS-10
ARSENIC 9.2 mg/kg
LEAD 10.5 mg/kg
ZINC 53.0 mg/kg
40-2-SS-8
LEAD 12.9 mg/kg
ZINC 72.4 mg/kg
40-2-SS-1
LEAD 11.0 mg/kg
40-2-SB-1-2.5
ARSENIC 10 mg/kg
BARIUM 177 mg/kg
LEAD 11.2 mg/kg
MANGANESE 370 mg/kg
ZINC 52.6 mg/kg
40-2-SB-1-5-99
ARSENIC 11.4 mg/kg
LEAD 8.6 mg/kg
40-2-SB-1-10.0
CALCIUM 26,900 mg/kg
40-2-SS-5
LEAD 9.5 mg/kg
40-2-SS-2
LEAD 13.3 mg/kg
40-2-SS-2-99
ARSENIC 10.9 mg/kg
LEAD 17.2 mg/kg
ZINC 70.3 mg/kg
40-2-SS-3
ARSENIC 9.6 mg/kg
CADMIUM 0.5 mg/kg
LEAD 259 mg/kg
ZINC 213 mg/kg
40-2-SS-4
ARSENIC 9.4 mg/kg
LEAD 30.1 mg/kg
ZINC 74.5 mg/kg
40-2-SS-6
ARSENIC 9.2 mg/kg
LEAD 11.6 mg/kg
ZINC 52.8 mg/kg
40-2-SB-3-2.5
ARSENIC 10 mg/kg
LEAD 8.3 mg/kg
ZINC 51.8 mg/kg
40-2-SB-3-5.0
LEAD 8.0 mg/kg
40-2-SB-3-10.0
BARIUM 195 mg/kg
CALCIUM 31,600 mg/kg
40-2-SS-7
LEAD 9.4 mg/kg
40-2-SB-4-2.5
ARSENIC 9.2 mg/kg
LEAD 8.5 mg/kg
40-2-SB-4-5.0
LEAD 8.2 mg/kg
40-2-SB-4-10.0
BARIUM 195 mg/kg
LEAD 8.1 mg/kg
CALCIUM 30,100 mg/kg
40-2-SB-2-5.0
ARSENIC 9.5 mg/kg
LEAD 7.7 mg/kg
40-2-SB-2-10.0
CALCIUM 40,300 mg/kg
40-2-SB-2-10-99
CALCIUM 49,800 mg/kg
40-2-SB-5-2.5
ARSENIC 10.5 mg/kg
BARIUM 194 mg/kg
LEAD 9.7 mg/kg
MANGANESE 502 mg/kg
40-2-SB-5-5.0
ARSENIC 10.9 mg/kg
BARIUM 176 mg/kg
LEAD 8.5 mg/kg
40-2-SB-5-10.0
ARSENIC 187 mg/kg
CALCIUM 47,800 mg/kg
MWH
NTC, FORT IRWIN, CA
SITE FTIR-40 AREA 2
PLANT TISSUE/SURFACE
SOIL AND SOIL BORING
SAMPLE RESULTS
FIGURE 4-9
REFERENCE FILES
1) babdr.dgn
FILE: $$$$$$$$$$$$$$$$directory/filename$$$$$$$$$$$$$$$$$$$ DATE: $$$$date$$$$ SCALE: $$scale$$
JOB No.



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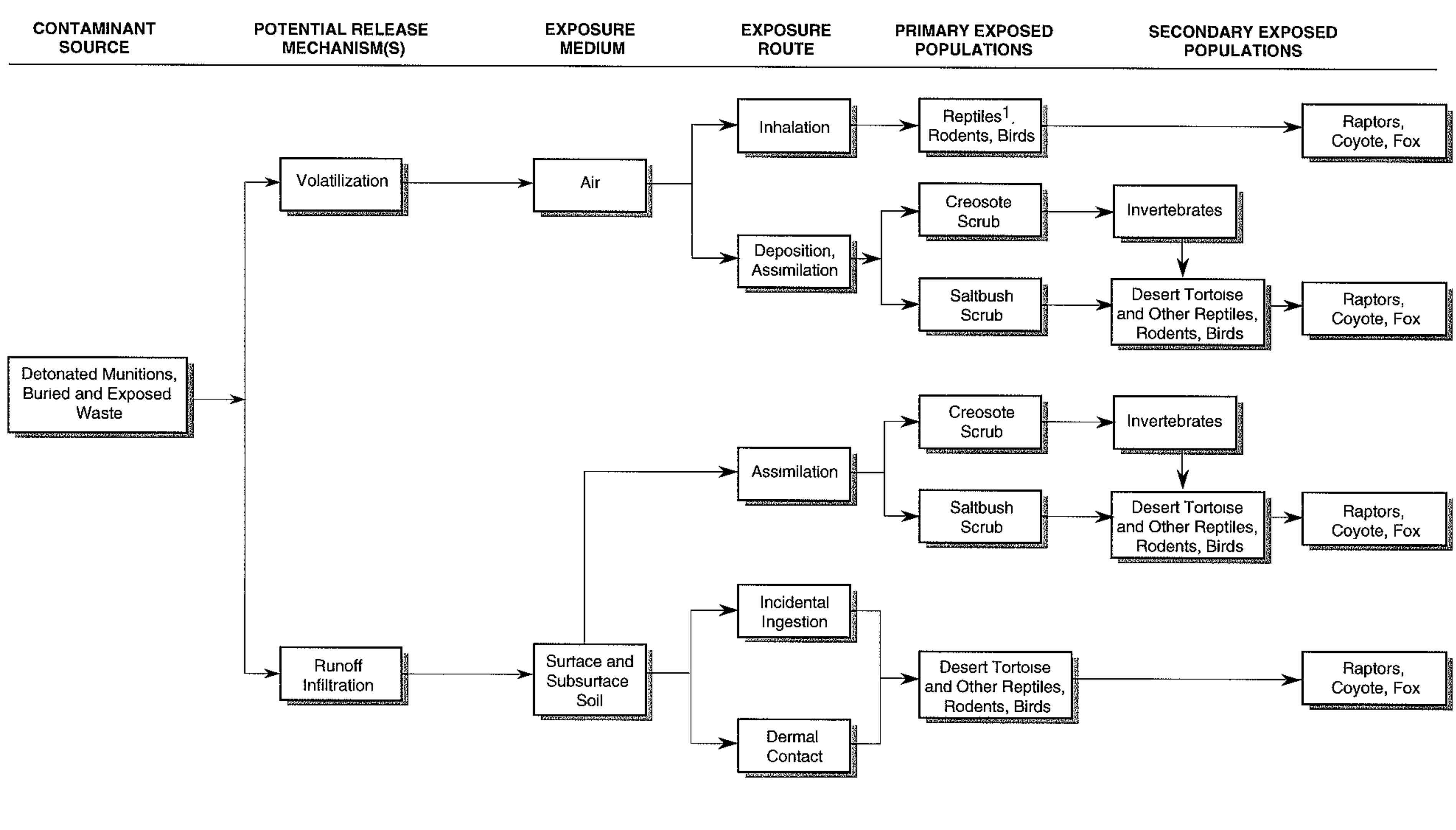
NTC, FORT IRWIN, CA

GENERALIZED CONCEPTUAL SITE MODEL FOR HUMAN RECEPTORS

FIGURE 6-1

01-03.FI

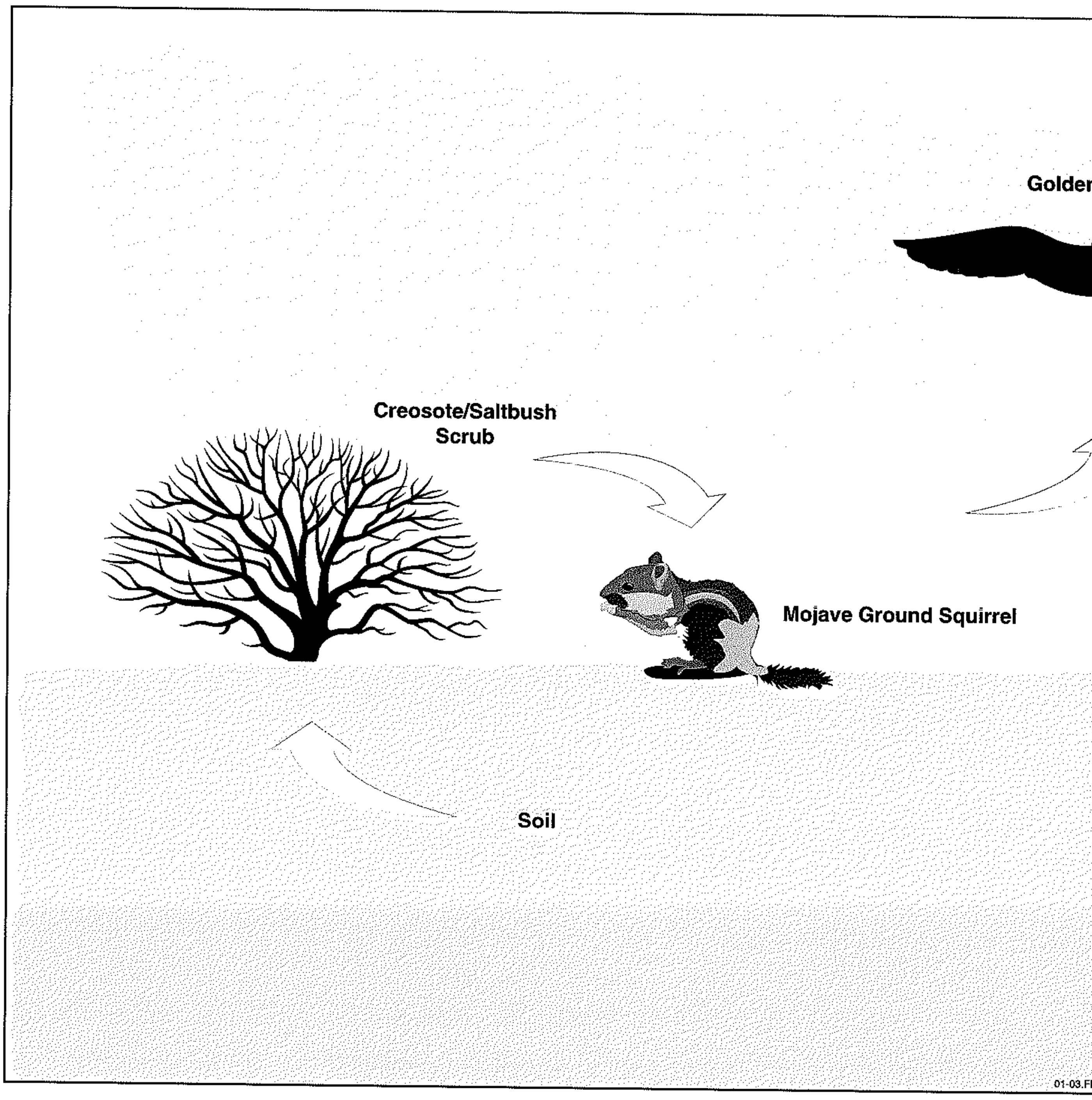


MWH

NTC, FORT IRWIN, CA

ECOLOGICAL CONCEPTUAL SITE MODEL

FIGURE 7-1

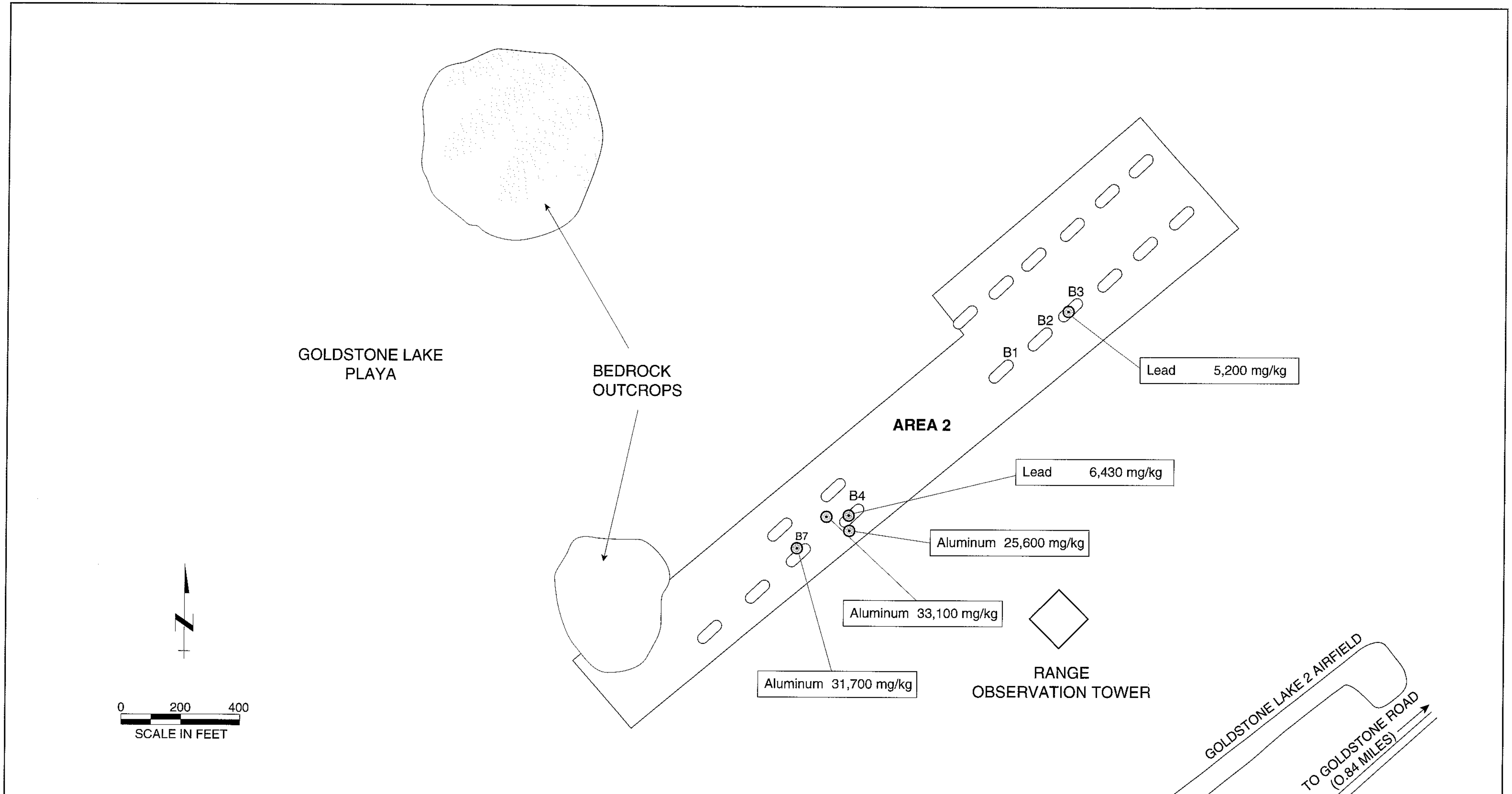


MWH

NTC, FORT IRWIN

SIMPLIFIED EXPOSURE MODEL

FIGURE 7-2



LEGEND

· SOIL SAMPLE LOCATION

B1 BERM

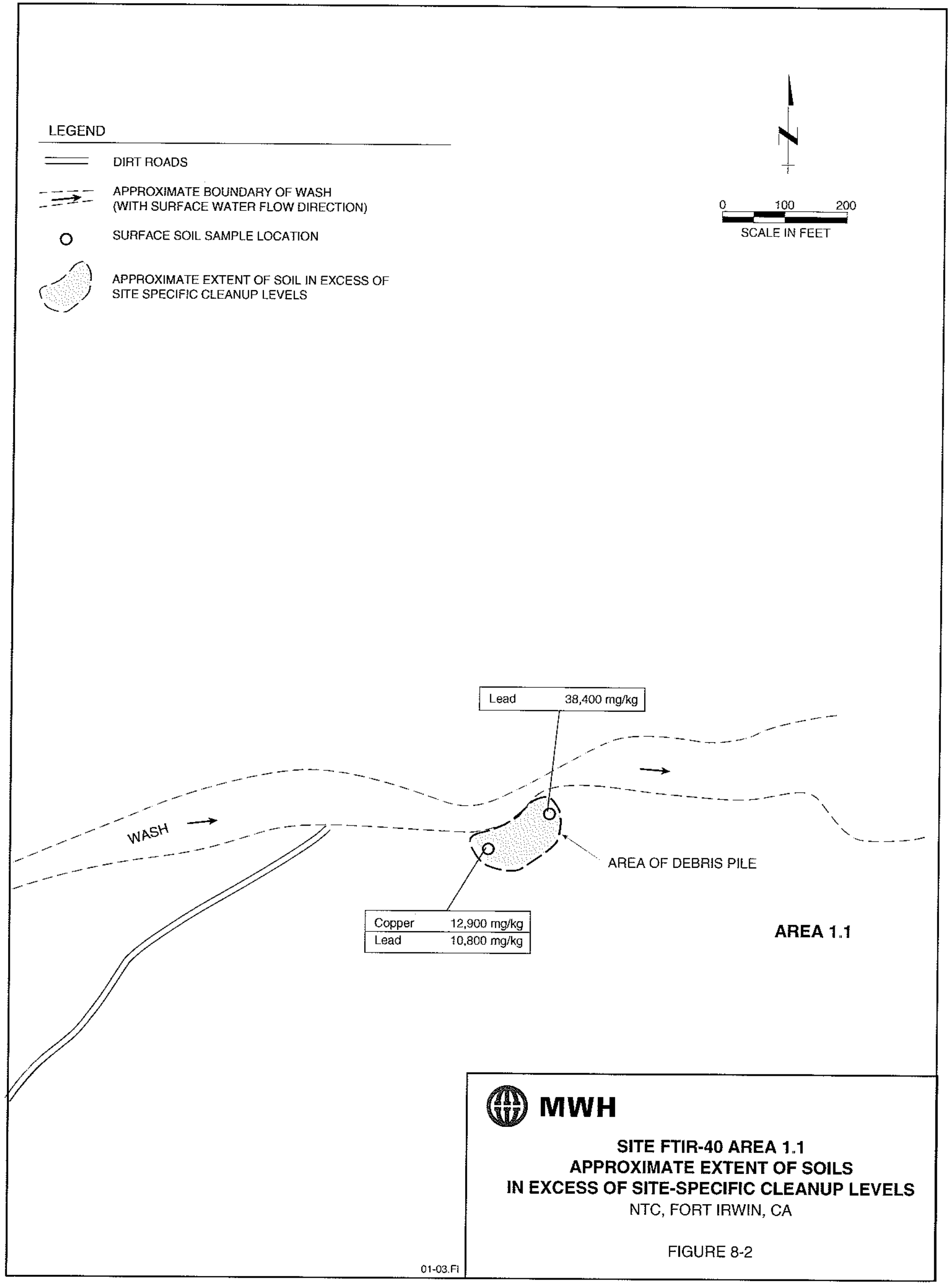
APPROXIMATE EXTENT OF SOILS IN EXCESS OF SITE-SPECIFIC CLEANUP GOALS

MWH

SITE FTIR-38 AREA 2
APPROXIMATE EXTENT OF SOILS IN EXCESS OF SITE-SPECIFIC CLEANUP LEVELS
NTC, FORT IRWIN, CA

FIGURE 8-1

01-03.FI



MWH

SITE FTIR-40 AREA 1.1
APPROXIMATE EXTENT OF SOILS
IN EXCESS OF SITE-SPECIFIC CLEANUP LEVELS
NTC, FORT IRWIN, CA

FIGURE 8-2

TABLE 1-1

**SUMMARY OF PROPOSED ACTIVITES
FOR SITES FTIR-38 AND FTIR-40
NATIONAL TRAINING CENTER, FORT IRWIN**

SITE	PREVIOUS INVESTIGATIONS	RESULTS	DATA REQUIRED	PROPOSED ACTIVITIES
FTIR-38 Area 1	Five surface soil samples	Elevated concentrations of metals	Subsurface Soil Samples (completed by USACE in 1998)	Determine Vertical Extent of Metal Contamination
	Screening HHRA risk	Excess Screening HHRA risk	Subsurface Soil Samples (completed by USACE in 1998)	Calculate Baseline HHRA using maximum concentrations
	Screening ERA risk	Lack of Significant Ecological Habitat	None	None
FTIR-38 Area 2	Soil samples at four embankments with highest visible metal debris.	Elevated concentrations of metals	XRF Samples	Determine Nature and Extent of Lead Contamination
	Screening HHRA risk	Excess screening HHRA risk.	XRF Samples	Re-evaluate lead using Lead Risk Spreadsheet
				Calculate Baseline HHRA using 95% UCLs
	Screening ERA risk	Excess screening ERA risk.	Plant Tissue	Phase II validation study.
			XRF Samples	Calculate baseline ERA using 95% UCL

TABLE 1-1

SUMMARY OF PROPOSED ACTIVITES
FOR SITES FTIR-38 AND FTIR-40
NATIONAL TRAINING CENTER, FORT IRWIN

SITE	PREVIOUS INVESTIGATIONS	RESULTS	DATA REQUIRED	PROPOSED ACTIVITIES
FTIR-40 Area 1.1	One test pit was excavated	Noticiable debris in the form of glass, metal, tar and wood were detected at 5 feet bgs.	None	None
	Soil samples	Elevated concentrations of metals and TRPH	None	None
	Screening HHRA risk	Excess screening HHRA risk.	Surface Soil Samples	Calculate Baseline HHRA using 95% UCL
	Screening ERA risk	Excess screening ERA risk.	Plant Tissue samples	Phase II validation study. Calculate baseline ERA using 95% UCL
FTIR-40 Area 2	One test pit was excavated	Decomposed wood and discolored soil were observed.	None	None
	Soil samples	Several SVOCs, metals, and TRPH were detected.	Soil Boring Samples	Delineate Vertical Extent of Contamination
	Screening HHRA risk	Excess screening HHRA risk.	Soil Boring Samples	Calculate Baseline HHRA using 95% UCLs
	Screening ERA risk	Excess screening ERA risk.	Plant Tissue samples	Phase II validation study. Calculate baseline ERA using 95% UCL

Notes:
ERA = ecological risk assessment
HHRA = human health risk assessment
SVOC = semi-volatile organic compound
TRPH = total recoverable petroleum hydrocarbons
UCL = upper confidence limit
XRF = x-ray fluorescence

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
FTIR-38 Area 1	38-1-SS-2-2	300428-0001	07/19/98	X		X		X			
	38-1-SS-2-5	300428-0002	07/19/98	X		X		X			
FTIR-38 Area 2	38-2-PT-1	99-3554-21	05/10/99			X					
	38-2-PT-1A	99-3593-7	05/11/99			X					
	38-2-PT-2A	99-3593-8	05/11/99			X					
	38-2-PT-3A	99-3593-9	05/11/99			X					
	38-2-PT-3A-99	99-3593-10	05/11/99			X					
	38-2-PT-4	99-3593-1	05/11/99			X					
	38-2-PT-5	99-3593-2	05/11/99			X					
	38-2-PT-6	99-3593-3	05/11/99			X					
	38-2-PT-7	99-3593-4	05/11/99			X					
	38-2-PT-8	99-3593-5	05/11/99			X					
	38-2-PT-9	99-3593-6	05/11/99			X					
	38-2-SS-1	99-3554-2	05/10/99	X		X					
	38-2-SS-1A	99-3593-19	05/11/99	X		X					
	38-2-SS-2	99-3593-11	05/11/99	X		X					
	38-2-SS-3	99-3593-12	05/11/99	X		X					
	38-2-SS-3-99	99-3593-20	05/11/99	X		X					
	38-2-SS-4	99-3593-13	05/11/99	X		X					
	38-2-SS-5	99-3593-14	05/11/99	X		X					
	38-2-SS-6	99-3593-15	05/11/99	X		X					
	38-2-SS-7	99-3593-16	05/11/99	X		X					
	38-2-SS-8	99-3593-17	05/11/99	X		X					
	38-2-SS-9	99-3593-18	05/11/99	X		X					
	38-2-SS-11	FI01-01	05/13/99		X						
	38-2-SS-11-1	FI01-21	05/13/99		X						
	38-2-SS-12	FI01-02	05/13/99		X						
	38-2-SS-12-1	FI01-22	05/13/99		X						
	38-2-SS-13	FI01-03	05/13/99		X						
	38-2-SS-13-1	FI01-23	05/13/99		X						
	38-2-SS-14	FI01-04	05/13/99		X						
	38-2-SS-14-1	FI01-24	05/13/99		X						
	38-2-SS-15	FI01-05	05/13/99		X						
	38-2-SS-16	FI01-06	05/13/99		X						
	38-2-SS-17	FI01-07	05/13/99		X						
	38-2-SS-18	FI01-08	05/13/99		X						
	38-2-SS-19	FI01-09	05/13/99		X						
	38-2-SS-20	FI01-10	05/13/99		X						
	38-2-SS-21	FI01-11	05/13/99		X						

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	38-2-SS-22	FI01-12	05/13/99		X						
	38-2-SS-22-99	FI01-13	05/13/99		X						
	38-2-SS-23	FI01-14	05/13/99		X						
	38-2-SS-24	FI01-15	05/13/99		X						
	38-2-SS-25	FI01-16	05/13/99		X						
	38-2-SS-26	FI01-17	05/13/99		X						
	38-2-SS-27	FI01-18	05/13/99		X						
	38-2-SS-28	FI01-19	05/13/99		X						
	38-2-SS-28-99	FI01-20	05/13/99		X						
	38-2-SS-29	FI01-25	05/13/99		X						
	38-2-SS-30	FI01-26	05/13/99		X						
	38-2-SS-31	FI01-27	05/13/99		X						
	38-2-SS-32	FI01-28	05/13/99		X						
	38-2-SS-33	FI01-29	05/13/99		X						
	38-2-SS-33-99	FI01-33	05/13/99		X						
	38-2-SS-34	FI01-30	05/13/99		X						
	38-2-SS-35	FI01-31	05/13/99		X						
	38-2-SS-36	FI01-32	05/13/99		X						
	38-2-SS-37	FI02-01	05/14/99		X						
	38-2-SS-38	FI02-02	05/14/99		X						
	38-2-SS-39	FI02-03	05/14/99		X						
	38-2-SS-40	FI02-04	05/14/99		X						
	38-2-SS-41	FI02-05	05/14/99		X						
	38-2-SS-42	FI02-06	05/14/99		X						
	38-2-SS-43	FI02-07	05/14/99		X						
	38-2-SS-44	FI02-08	05/14/99		X						
	38-2-SS-45	FI02-09	05/14/99		X						
	38-2-SS-46	FI02-10	05/14/99		X						
	38-2-SS-47	FI02-11	05/14/99		X						
	38-2-SS-48	FI02-12	05/14/99		X						
	38-2-SS-49	FI02-13	05/14/99		X						
	38-2-SS-50	FI02-14	05/14/99		X						
	38-2-SS-51	FI02-15	05/14/99		X						
	38-2-SS-52	FI02-16	05/14/99		X						
	38-2-SS-52-99	FI02-19	05/14/99		X						
	38-2-SS-53	FI02-17	05/14/99		X						
	38-2-SS-54	FI02-18	05/14/99		X						
	38-2-SS-55	FI02-20	05/14/99		X						
	38-2-SS-56	FI02-21	05/14/99		X						

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	38-2-SS-57	FI02-22	05/14/99		X						
	38-2-SS-58	FI02-23	05/14/99		X						
	38-2-SS-59	FI02-24	05/14/99		X						
	38-2-SS-59-99	FI02-25	05/14/99		X						
	38-2-SS-60	FI02-26	05/14/99		X						
	38-2-SS-61	FI02-27	05/14/99		X						
	38-2-SS-62	FI02-28	05/14/99		X						
	38-2-SS-63	FI02-29	05/14/99		X						
	38-2-SS-64	FI02-30	05/14/99		X						
	38-2-SS-65	FI02-31	05/14/99		X						
	38-2-SS-66	FI02-32	05/14/99		X						
	38-2-SS-67	FI02-33	05/14/99		X						
	38-2-SS-68	FI02-34	05/14/99		X						
	38-2-SS-69	FI02-35	05/14/99		X						
	38-2-SS-70	FI02-36	05/14/99		X						
	38-2-SS-30-1	FI03-24	05/15/99		X						
	38-2-SS-37-1	FI03-01	05/15/99		X						
	38-2-SS-38-1	FI03-02	05/15/99		X						
	38-2-SS-38-1-99	FI03-05	05/15/99		X						
	38-2-SS-39-1	FI03-03	05/15/99		X						
	38-2-SS-40-1	FI03-04	05/15/99		X						
	38-2-SS-41-1	FI03-06	05/15/99		X						
	38-2-SS-42-1	FI03-07	05/15/99		X						
	38-2-SS-49-1	FI03-08	05/15/99		X						
	38-2-SS-50-1	FI03-09	05/15/99		X						
	38-2-SS-51-1	FI03-10	05/15/99		X						
	38-2-SS-52-1	FI03-11	05/15/99		X						
	38-2-SS-53-1	FI03-12	05/15/99		X						
	38-2-SS-54-1	FI03-13	05/15/99		X						
	38-2-SS-54-1-99	FI03-14	05/15/99		X						
	38-2-SS-59-1	FI03-15	05/15/99		X						
	38-2-SS-60-1	FI03-17	05/15/99		X						
	38-2-SS-60-1-99	FI03-19	05/15/99		X						
	38-2-SS-61-1	FI03-20	05/15/99		X						
	38-2-SS-62-1	FI03-22	05/15/99		X						
	38-2-SS-65-1	FI03-25	05/15/99		X						
	38-2-SS-66-1	FI03-27	05/15/99		X						
	38-2-SS-67-1	FI03-29	05/15/99		X						
	38-2-SS-68-1	FI03-31	05/15/99		X						

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	38-2-SS-69-1	FI03-33	05/15/99		X						
	38-2-SS-70-1	FI03-35	05/15/99		X						
	38-2-SS-71	FI03-16	05/15/99		X						
	38-2-SS-72	FI03-18	05/15/99		X						
	38-2-SS-73	FI03-21	05/15/99		X						
	38-2-SS-74	FI03-23	05/15/99		X						
	38-2-SS-75	FI03-26	05/15/99		X						
	38-2-SS-76	FI03-28	05/15/99		X						
	38-2-SS-77	FI03-30	05/15/99		X						
	38-2-SS-78	FI03-32	05/15/99		X						
	38-2-SS-79	FI03-34	05/15/99		X						
	38-2-SS-80	FI03-36	05/15/99		X						
	38-2-SS-100	FI04-32	05/16/99		X						
	38-2-SS-11-2	FI04-39	05/16/99		X						
	38-2-SS-11-2-99	FI04-45	05/16/99		X						
	38-2-SS-12-2	FI04-40	05/16/99		X						
	38-2-SS-13-2	FI04-41	05/16/99		X						
	38-2-SS-14-2	FI04-42	05/16/99		X						
	38-2-SS-16-1	FI04-44	05/16/99		X						
	38-2-SS-23-1	FI04-33	05/16/99		X						
	38-2-SS-24-1	FI04-34	05/16/99		X						
	38-2-SS-25-1	FI04-35	05/16/99		X						
	38-2-SS-26-1	FI04-36	05/16/99		X						
	38-2-SS-27-1	FI04-37	05/16/99		X						
	38-2-SS-28-1	FI04-38	05/16/99		X						
	38-2-SS-31-1	FI04-43	05/16/99		X						
	38-2-SS-37-2	FI04-02	05/16/99		X						
	38-2-SS-38-2	FI04-04	05/16/99		X						
	38-2-SS-39-2	FI04-06	05/16/99		X						
	38-2-SS-40-2	FI04-08	05/16/99		X						
	38-2-SS-49-2	FI04-13	05/16/99		X						
	38-2-SS-50-2	FI04-15	05/16/99		X						
	38-2-SS-50-2-99	FI04-24	05/16/99		X						
	38-2-SS-51-1.5	FI04-17	05/16/99		X						
	38-2-SS-52-1.5	FI04-19	05/16/99		X						
	38-2-SS-53-2	FI04-21	05/16/99		X						
	38-2-SS-54-2	FI04-23	05/16/99		X						
	38-2-SS-81	FI04-01	05/16/99		X						
	38-2-SS-82	FI04-03	05/16/99		X						

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 5 of 15)

Site	Field Sample ID	Laboratory ID	Date Sampled	Analyses Requested							
				Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	38-2-SS-83	FI04-05	05/16/99		X						
	38-2-SS-84	FI04-07	05/16/99		X						
	38-2-SS-84-99	FI04-10	05/16/99		X						
	38-2-SS-85	FI04-09	05/16/99		X						
	38-2-SS-86	FI04-11	05/16/99		X						
	38-2-SS-87	FI04-12	05/16/99		X						
	38-2-SS-88	FI04-14	05/16/99		X						
	38-2-SS-89	FI04-16	05/16/99		X						
	38-2-SS-90	FI04-18	05/16/99		X						
	38-2-SS-91	FI04-20	05/16/99		X						
	38-2-SS-92	FI04-22	05/16/99		X						
	38-2-SS-93	FI04-25	05/16/99		X						
	38-2-SS-94	FI04-26	05/16/99		X						
	38-2-SS-95	FI04-27	05/16/99		X						
	38-2-SS-96	FI04-28	05/16/99		X						
	38-2-SS-97	FI04-29	05/16/99		X						
	38-2-SS-98	FI04-30	05/16/99		X						
	38-2-SS-99	FI04-31	05/16/99		X						
	38-2-SS-101	FI05-01	05/17/99		X						
	38-2-SS-102	FI05-02	05/17/99		X						
	38-2-SS-103	FI05-03	05/17/99		X						
	38-2-SS-103-99	FI05-04	05/17/99		X						
	38-2-SS-104	FI05-05	05/17/99		X						
	38-2-SS-104-99	FI05-06	05/17/99		X						
	38-2-SS-105	FI05-07	05/17/99		X						
	38-2-SS-105-99	FI05-08	05/17/99		X						
	38-2-SS-106	FI05-09	05/17/99		X						
	38-2-SS-106-99	FI05-10	05/17/99		X						
	38-2-SS-107	FI05-11	05/17/99		X						
	38-2-SS-107-99	FI05-12	05/17/99		X						
	38-2-SS-108	FI05-13	05/17/99		X						
	38-2-SS-108-99	FI05-14	05/17/99		X						
	38-2-SS-109	FI05-15	05/17/99		X						
	38-2-SS-109-99	FI05-16	05/17/99		X						
	38-2-SS-110	FI05-17	05/17/99		X						
	38-2-SS-111	FI05-18	05/17/99		X						
	38-2-SS-112	FI05-19	05/17/99		X						
	38-2-SS-113	FI05-20	05/17/99		X						
	38-2-SS-114	FI05-21	05/17/99		X						

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	38-2-SS-23-2	FI05-22	05/17/99		X						
	38-2-SS-24-2	FI05-23	05/17/99		X						
	38-2-SS-25-2	FI05-24	05/17/99		X						
	38-2-SS-26-2	FI05-25	05/17/99		X						
	38-2-SS-27-2	FI05-26	05/17/99		X						
	38-2-SS-28-2	FI05-27	05/17/99		X						
	38-2-SS-115	FI06-04	05/18/99		X						
	38-2-SS-116	FI06-06	05/18/99		X						
	38-2-SS-117	FI06-09	05/18/99		X						
	38-2-SS-118	FI06-12	05/18/99		X						
	38-2-SS-119	FI06-13	05/18/99		X						
	38-2-SS-120	FI06-16	05/18/99		X						
	38-2-SS-121	FI06-20	05/18/99		X						
	38-2-SS-122	FI06-24	05/18/99		X						
	38-2-SS-123	FI06-30	05/18/99		X						
	38-2-SS-124	FI06-22	05/18/99		X						
	38-2-SS-125	FI06-26	05/18/99		X						
	38-2-SS-126	FI06-29	05/18/99		X						
	38-2-SS-127	FI06-32	05/18/99		X						
	38-2-SS-128	FI06-33	05/18/99		X						
	38-2-SS-129	FI06-34	05/18/99		X						
	38-2-SS-130	FI06-35	05/18/99		X						
	38-2-SS-131	FI06-36	05/18/99		X						
	38-2-SS-132	FI06-37	05/18/99		X						
	38-2-SS-133	FI06-38	05/18/99		X						
	38-2-SS-31-2	FI06-15	05/18/99		X						
	38-2-SS-37-3	FI06-01	05/18/99		X						
	38-2-SS-37-3-99	FI06-02	05/18/99		X						
	38-2-SS-38-3	FI06-05	05/18/99		X						
	38-2-SS-49-3	FI06-17	05/18/99		X						
	38-2-SS-50-3	FI06-18	05/18/99		X						
	38-2-SS-51-3	FI06-19	05/18/99		X						
	38-2-SS-51-3-99	FI06-23	05/18/99		X						
	38-2-SS-53-3	FI06-27	05/18/99		X						
	38-2-SS-53-3-99	FI06-28	05/18/99		X						
	38-2-SS-81-1	FI06-03	05/18/99		X						
	38-2-SS-82-1	FI06-07	05/18/99		X						
	38-2-SS-82-1-99	FI06-08	05/18/99		X						
	38-2-SS-83-1	FI06-10	05/18/99		X						

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	38-2-SS-84-1	FI06-11	05/18/99		X						
	38-2-SS-85-1	FI06-14	05/18/99		X						
	38-2-SS-89-1	FI06-21	05/18/99		X						
	38-2-SS-90-1	FI06-25	05/18/99		X						
	38-2-SS-91-1	FI06-31	05/18/99		X						
	38-2-SS-103-1	FI07-07	05/19/99		X						
	38-2-SS-103-1-99	FI07-08	05/19/99		X						
	38-2-SS-105-1	FI07-15	05/19/99		X						
	38-2-SS-108-1	FI07-19	05/19/99		X						
	38-2-SS-111-1	FI07-36	05/19/99		X						
	38-2-SS-112-1	FI07-28	05/19/99		X						
	38-2-SS-112-1-99	FI07-35	05/19/99		X						
	38-2-SS-11-3	FI07-01	05/19/99		X						
	38-2-SS-115-1	FI07-05	05/19/99		X						
	38-2-SS-115-2	FI07-42	05/19/99		X						
	38-2-SS-116	FI07-40	05/19/99		X						
	38-2-SS-116-1	FI07-30	05/19/99		X						
	38-2-SS-116-1-99	FI07-31	05/19/99		X						
	38-2-SS-118-1	FI07-13	05/19/99		X						
	38-2-SS-12-3	FI07-06	05/19/99		X						
	38-2-SS-12-4	FI07-38	05/19/99		X						
	38-2-SS-12-4-99	FI07-39	05/19/99		X						
	38-2-SS-125-1	FI07-33	05/19/99		X						
	38-2-SS-126-1	FI07-26	05/19/99		X						
	38-2-SS-134	FI07-04	05/19/99		X						
	38-2-SS-135	FI07-09	05/19/99		X						
	38-2-SS-136	FI07-10	05/19/99		X						
	38-2-SS-137	FI07-14	05/19/99		X						
	38-2-SS-138	FI07-16	05/19/99		X						
	38-2-SS-139	FI07-20	05/19/99		X						
	38-2-SS-140	FI07-21	05/19/99		X						
	38-2-SS-141	FI07-27	05/19/99		X						
	38-2-SS-142	FI07-29	05/19/99		X						
	38-2-SS-143	FI07-34	05/19/99		X						
	38-2-SS-144	FI07-44	05/19/99		X						
	38-2-SS-145	FI07-37	05/19/99		X						
	38-2-SS-30-2	FI07-17	05/19/99		X						
	38-2-SS-37-4	FI07-02	05/19/99		X						
	38-2-SS-37-4-99	FI07-03	05/19/99		X						

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	38-2-SS-37-5	FI07-41	05/19/99		X						
	38-2-SS-39-3	FI07-11	05/19/99		X						
	38-2-SS-52-3	FI07-24	05/19/99		X						
	38-2-SS-54-3	FI07-45	05/19/99		X						
	38-2-SS-62-2	FI07-12	05/19/99		X						
	38-2-SS-67-2	FI07-23	05/19/99		X						
	38-2-SS-73-1	FI07-43	05/19/99		X						
	38-2-SS-75-1	FI07-18	05/19/99		X						
	38-2-SS-77-1	FI07-22	05/19/99		X						
	38-2-SS-78-1	FI07-25	05/19/99		X						
	38-2-SS-79-1	FI07-32	05/19/99		X						
	38-2-SS-113-1	FI08-2	05/20/99		X						
	38-2-SS-12-5	FI08-23	05/20/99		X						
	38-2-SS-142-1	FI08-8	05/20/99		X						
	38-2-SS-142-1-99	FI08-10	05/20/99		X						
	38-2-SS-146	FI08-3	05/20/99		X						
	38-2-SS-146-99	FI08-4	05/20/99		X						
	38-2-SS-147	FI08-9	05/20/99		X						
	38-2-SS-148	FI08-13	05/20/99		X						
	38-2-SS-149	FI08-20	05/20/99		X						
	38-2-SS-150	FI08-19	05/20/99		X						
	38-2-SS-151	FI08-5	05/20/99		X						
	38-2-SS-152	FI08-7	05/20/99		X						
	38-2-SS-153	FI08-12	05/20/99		X						
	38-2-SS-154	FI08-14	05/20/99		X						
	38-2-SS-155	FI08-15	05/20/99		X						
	38-2-SS-156	FI08-16	05/20/99		X						
	38-2-SS-157	FI08-21	05/20/99		X						
	38-2-SS-158	FI08-22	05/20/99		X						
	38-2-SS-159	FI08-24	05/20/99		X						
	38-2-SS-160	FI08-25	05/20/99		X						
	38-2-SS-26-3	FI08-11	05/20/99		X						
	38-2-SS-27-3	FI08-6	05/20/99		X						
	38-2-SS-49-4	FI08-17	05/20/99		X						
	38-2-SS-49-4-99	FI08-18	05/20/99		X						
	38-2-SS-70-2	FI08-1	05/20/99		X						
	38-2-SS-161	FI09-01	05/21/99		X						
	38-2-SS-162	FI09-02	05/21/99		X						
	38-2-SS-163	FI09-03	05/21/99		X						

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	38-2-SS-163-99	FI09-05	05/21/99		X						
	38-2-SS-164	FI09-04	05/21/99		X						
	38-2-SS-165	FI09-06	05/21/99		X						
	38-2-SS-166	FI09-07	05/21/99		X						
	38-2-SS-167	FI09-08	05/21/99		X						
	38-2-SS-168	FI09-09	05/21/99		X						
	38-2-SS-169	FI09-10	05/21/99		X						
	38-2-SS-170	FI09-16	05/21/99		X						
	38-2-SS-171	FI09-11	05/21/99		X						
	38-2-SS-172	FI09-12	05/21/99		X						
	38-2-SS-172-99	FI09-13	05/21/99		X						
	38-2-SS-173	FI09-14	05/21/99		X						
	38-2-SS-174	FI09-15	05/21/99		X						
	38-2-SS-175	FI09-17	05/21/99		X						
	38-2-SS-176	FI09-18	05/21/99		X						
	38-2-SS-177	FI09-19	05/21/99		X						
	38-2-SS-178	FI09-20	05/21/99		X						
	38-2-SS-179	FI09-21	05/21/99		X						
	38-2-SS-180	FI09-22	05/21/99		X						
	38-2-SS-181	FI09-23	05/21/99		X						
	38-2-SS-182	FI09-24	05/21/99		X						
	38-2-SS-182-99	FI09-27	05/21/99		X						
	38-2-SS-183	FI09-25	05/21/99		X						
	38-2-SS-184	FI09-26	05/21/99		X						
	38-2-SS-185	FI09-28	05/21/99		X						
	38-2-SS-186	FI09-29	05/21/99		X						
	38-2-SS-187	FI09-30	05/21/99		X						
	38-2-SS-188	FI09-31	05/21/99		X						
	38-2-SS-189	FI09-32	05/21/99		X						
	38-2-SS-190	FI09-33	05/21/99		X						
	38-2-SS-190-99	FI09-34	05/21/99		X						
	38-2-SS-191	FI09-35	05/21/99		X						
	38-2-SS-192	FI09-36	05/21/99		X						
	38-2-SS-193	FI10-01	05/22/99		X						
	38-2-SS-194	FI10-02	05/22/99		X						
	38-2-SS-194-99	FI10-03	05/22/99		X						
	38-2-SS-195	FI10-04	05/22/99		X						
	38-2-SS-196	FI10-05	05/22/99		X						
	38-2-SS-197	FI10-06	05/22/99		X						

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	38-2-SS-198	FI10-07	05/22/99		X						
	38-2-SS-199	FI10-08	05/22/99		X						
	38-2-SS-200	FI10-09	05/22/99		X						
	38-2-SS-201	FI10-10	05/22/99		X						
	38-2-SS-201-99	FI10-11	05/22/99		X						
	38-2-SS-202	FI10-12	05/22/99		X						
	38-2-SS-203	FI10-13	05/22/99		X						
	38-2-SS-204	FI10-14	05/22/99		X						
	38-2-SS-205	FI10-15	05/22/99		X						
	38-2-SS-206	FI10-16	05/22/99		X						
	38-2-SS-207	FI10-17	05/22/99		X						
	38-2-SS-207-99	FI10-18	05/22/99		X						
	38-2-SS-208	FI10-19	05/22/99		X						
	38-2-SS-209	FI10-20	05/22/99		X						
	38-2-SS-210	FI10-21	05/22/99		X						
	38-2-SS-211	FI10-22	05/22/99		X						
	38-2-SS-212	FI10-23	05/22/99		X						
	38-2-SS-213	FI10-24	05/22/99		X						
	38-2-SS-214	FI10-25	05/22/99		X						
	38-2-SS-215	FI10-26	05/22/99		X						
	38-2-SS-216	FI10-27	05/22/99		X						
	38-2-SS-217	FI10-28	05/22/99		X						
	38-2-SS-218	FI10-29	05/22/99		X						
	38-2-SS-219	FI10-30	05/22/99		X						
	38-2-SS-CNF-11-1'	99-3606-12	05/13/99	X		X					
	38-2-SS-CNF-12-1'	99-3606-13	05/13/99	X		X					
	38-2-SS-CNF-14	99-3606-1	05/13/99				X				
	38-2-SS-CNF-14-1'	99-3606-14	05/13/99	X		X					
	38-2-SS-CNF-20	99-3606-2	05/13/99	X		X					
	38-2-SS-CNF-22	99-3606-3	05/13/99	X		X					
	38-2-SS-CNF-23	99-3606-4	05/13/99	X		X					
	38-2-SS-CNF-25	99-3606-5	05/13/99	X		X					
	38-2-SS-CNF-27	99-3606-6	05/13/99				X				
	38-2-SS-CNF-28	99-3606-7	05/13/99	X		X					
	38-2-SS-CNF-29	99-3606-8	05/13/99	X		X					
	38-2-SS-CNF-30	99-3606-9	05/13/99	X		X					
	38-2-SS-CNF-33	99-3606-10	05/13/99	X		X					
	38-2-SS-CNF-36	99-3606-11	05/13/99	X		X					
	38-2-SS-CNF37	99-3645-1	05/14/99	X		X					

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	38-2-SS-CNF41	99-3645-2	05/14/99	X		X					
	38-2-SS-CNF42	99-3645-3	05/14/99	X		X					
	38-2-SS-CNF43	99-3645-4	05/14/99	X		X					
	38-2-SS-CNF45	99-3645-5	05/14/99	X		X					
	38-2-SS-CNF47	99-3645-6	05/14/99	X		X					
	38-2-SS-CNF49	99-3645-7	05/14/99	X		X					
	38-2-SS-CNF53	99-3645-8	05/14/99	X		X					
	38-2-SS-CNF101	99-3686-8	05/17/99	X		X					
	38-2-SS-CNF28-1	99-3686-9	05/16/99	X		X					
	38-2-SS-CNF37-1	99-3686-10	05/15/99	X		X					
	38-2-SS-CNF37-2	99-3686-11	05/16/99	X		X					
	38-2-SS-CNF42-1	99-3686-12	05/15/99	X		X					
	38-2-SS-CNF49-1	99-3686-13	05/15/99	X		X					
	38-2-SS-CNF49-2	99-3686-14	05/16/99	X		X					
	38-2-SS-CNF50-2	99-3686-15	05/16/99	X		X					
	38-2-SS-CNF53-2	99-3686-16	05/16/99	X		X					
	38-2-SS-CNF64	99-3686-1	05/14/99	X		X					
	38-2-SS-CNF66	99-3686-2	05/14/99	X		X					
	38-2-SS-CNF68-1	99-3686-17	05/15/99	X		X					
	38-2-SS-CNF74	99-3686-3	05/15/99	X		X					
	38-2-SS-CNF82	99-3686-4	05/16/99	X		X					
	38-2-SS-CNF84	99-3686-5	05/16/99	X		X					
	38-2-SS-CNF91	99-3686-6	05/16/99	X		X					
	38-2-SS-CNF92	99-3686-7	05/16/99	X		X					
	38-2-SS-CNF129	99-3755-1	05/18/99	X		X					
	38-2-SS-CNF133	99-3755-2	05/18/99	X		X					
	38-2-SS-CNF26-2'	99-3755-3	05/17/99	X		X					
	38-2-SS-CNF51-3'	99-3755-4	05/18/99	X		X					
	38-2-SS-CNF81-1'	99-3755-5	05/18/99	X		X					
	38-2-SS-CNF82-1'	99-3755-6	05/18/99	X		X					
	38-2-SS-CNF84-1'	99-3755-7	05/18/99	X		X					
	38-2-SS-CNF12-5	99-3802-1	05/20/99	X		X					
	38-2-SS-CNF126-1	99-3802-21	05/19/99	X		X					
	38-2-SS-CNF142	99-3802-2	05/19/99	X		X					
	38-2-SS-CNF143	99-3802-3	05/19/99	X		X					
	38-2-SS-CNF152	99-3802-4	05/20/99	X		X					
	38-2-SS-CNF155	99-3802-5	05/20/99	X		X					
	38-2-SS-CNF176	99-3802-6	05/21/99	X		X					
	38-2-SS-CNF179	99-3802-7	05/21/99	X		X					

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	38-2-SS-CNF182	99-3802-8	05/22/99	X		X					
	38-2-SS-CNF185	99-3802-9	05/21/99	X		X					
	38-2-SS-CNF188	99-3802-10	05/21/99	X		X					
	38-2-SS-CNF191	99-3802-11	05/21/99	X		X					
	38-2-SS-CNF193	99-3802-12	05/22/99	X		X					
	38-2-SS-CNF196	99-3802-13	05/22/99	X		X					
	38-2-SS-CNF200	99-3802-14	05/22/99	X		X					
	38-2-SS-CNF203	99-3802-15	05/22/99	X		X					
	38-2-SS-CNF210	99-3802-16	05/22/99	X		X					
	38-2-SS-CNF27-1	99-3802-17	05/20/99	X		X					
	38-2-SS-CNF70-1	99-3802-18	05/20/99	X		X					
	38-2-SS-CNF77-1	99-3802-19	05/19/99	X		X					
	38-2-SS-CNF79-1	99-3802-20	05/19/99	X		X					
Reference Area RF1	RF1-PT-1	99-3554-15	05/10/99			X					
	RF1-SS-1	99-3554-23	05/10/99	X		X					
	RF1-PT-1A	99-3593-57	05/11/99			X					
	RF1-PT-2A	99-3593-58	05/11/99			X					
	RF1-PT-3A	99-3593-59	05/11/99			X					
	RF1-PT-4A	99-3593-40	05/11/99			X					
	RF1-PT-4A-99	99-3593-41	05/11/99			X					
	RF1-PT-5A	99-3593-42	05/11/99			X					
	RF1-PT-6A	99-3593-43	05/11/99			X					
	RF1-PT-7A	99-3593-44	05/11/99			X					
	RF1-PT-8A	99-3593-45	05/11/99			X					
	RF1-PT-9A	99-3593-46	05/11/99			X					
	RF1-SS-1A	99-3593-60	05/11/99	X		X					
	RF1-SS-2A	99-3593-61	05/11/99	X		X					
	RF1-SS-3A	99-3593-62	05/11/99	X		X					
	RF1-SS-4A	99-3593-63	05/11/99	X		X					
	RF1-SS-4A-99	99-3593-64	05/11/99	X		X					
	RF1-SS-5A	99-3593-65	05/11/99	X		X					
	RF1-SS-6A	99-3593-66	05/11/99	X		X					
	RF1-SS-7A	99-3593-70	05/11/99	X		X					
	RF1-SS-8A	99-3593-67	05/11/99	X		X					
	RF1-SS-9A	99-3593-68	05/11/99	X		X					
FTIR-40 Area 1.1	40-1-PT-1	99-3593-21	05/11/99			X		X			
	40-1-PT-10	99-3593-30	05/11/99			X		X			
	40-1-PT-2	99-3593-22	05/11/99			X		X			

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	40-1-PT-3	99-3593-23	05/11/99			X		X			
	40-1-PT-3-99	99-3593-31	05/11/99			X		X			
	40-1-PT-4	99-3593-24	05/11/99			X		X			
	40-1-PT-5	99-3593-25	05/11/99			X		X			
	40-1-PT-6	99-3593-26	05/11/99			X		X			
	40-1-PT-7	99-3593-27	05/11/99			X		X			
	40-1-PT-8	99-3593-28	05/11/99			X		X			
	40-1-PT-9	99-3593-29	05/11/99			X		X			
	40-1-SS-1	99-3622-1	05/11/99	X		X		X			
	40-1-SS-10	99-3622-10	05/11/99	X		X		X			
	40-1-SS-2	99-3622-2	05/11/99	X		X		X			
	40-1-SS-3	99-3622-3	05/11/99	X		X		X			
	40-1-SS-3-99	99-3622-11	05/11/99	X		X		X			
	40-1-SS-4	99-3622-4	05/11/99	X		X		X			
	40-1-SS-5	99-3622-5	05/11/99	X		X		X			
	40-1-SS-6	99-3622-6	05/11/99	X		X		X			
	40-1-SS-7	99-3622-7	05/11/99	X		X		X			
	40-1-SS-8	99-3622-8	05/11/99	X		X		X			
	40-1-SS-9	99-3622-9	05/11/99	X		X		X			
FTIR-40 Area 2	40-2-PT-1	99-3554-16	05/10/99			X					
	40-2-PT-2	99-3554-17	05/10/99			X					
	40-2-PT-2-99	99-3554-19	05/10/99			X					
	40-2-PT-3	99-3554-18	05/10/99			X					
	40-2-PT-4	99-3554-22	05/10/99			X					
	40-2-PT-5	99-3554-20	05/10/99			X					
	40-2-SS-1	99-3554-9	05/10/99	X		X					
	40-2-SS-2	99-3554-10	05/10/99	X		X					
	40-2-SS-2-99	99-3554-14	05/10/99	X		X					
	40-2-SS-3	99-3554-11	05/10/99	X		X					
	40-2-SS-4	99-3554-12	05/10/99	X		X					
	40-2-SS-5	99-3554-13	05/10/99	X		X					
	40-2-PT-10	99-3593-36	05/11/99			X					
	40-2-PT-6	99-3593-32	05/11/99			X					
	40-2-PT-7	99-3593-33	05/11/99			X					
	40-2-PT-8	99-3593-34	05/11/99			X					
	40-2-PT-9	99-3593-35	05/11/99			X					
	40-2-SS-6	99-3593-37	05/11/99	X		X					
	40-2-SS-7	99-3593-38	05/11/99	X		X					
	40-2-SS-8	99-3593-39	05/11/99	X		X					

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

Site	Field Sample ID	Laboratory ID	Date Sampled	Analyses Requested							
				Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	40-2-SB-1-10.0	99-3622-15	05/12/99	X		X		X	X	X	X
	40-2-SB-1-2.5	99-3622-12	05/12/99	X		X		X	X	X	X
	40-2-SB-1-5-99	99-3622-13	05/12/99	X		X		X	X	X	X
	40-2-SB-1-5.0	99-3622-14	05/12/99	X		X		X	X	X	X
	40-2-SB-2-10-99	99-3622-19	05/12/99	X		X		X	X	X	X
	40-2-SB-2-10.0	99-3622-20	05/12/99	X		X		X	X	X	X
	40-2-SB-2-5.0	99-3622-18	05/12/99	X		X		X	X	X	X
	40-2-SB-3-10.0	99-3622-23	05/12/99	X		X		X	X	X	X
	40-2-SB-3-2.5	99-3622-21	05/12/99	X		X		X	X	X	X
	40-2-SB-3-5.0	99-3622-22	05/12/99	X		X		X	X	X	X
	40-2-SB-4-10.0	99-3622-26	05/12/99	X		X		X	X	X	X
	40-2-SB-4-2.5	99-3622-24	05/12/99	X		X		X	X	X	X
	40-2-SB-4-5.0	99-3622-25	05/12/99	X		X		X	X	X	X
	40-2-SB-5-10.0	99-3622-29	05/12/99	X		X		X	X	X	X
	40-2-SB-5-2.5	99-3622-27	05/12/99	X		X		X	X	X	X
	40-2-SB-5-5.0	99-3622-28	05/12/99	X		X		X	X	X	X
	40-2-SB-CUTTINGS	99-3622-30	05/12/99	X			X				
	40-2-SS-10	99-3622-32	05/11/99	X		X					
	40-2-SS-9	99-3622-31	05/11/99	X		X					
Reference Area RF2	RF2-PT-1	99-3593-47	05/11/99			X		X			
	RF2-PT-10	99-3593-55	05/11/99			X		X			
	RF2-PT-2	99-3593-48	05/11/99			X		X			
	RF2-PT-3	99-3593-49	05/11/99			X		X			
	RF2-PT-4	99-3593-69	05/11/99			X		X			
	RF2-PT-4-99	99-3593-56	05/11/99			X		X			
	RF2-PT-5	99-3593-50	05/11/99			X		X			
	RF2-PT-6	99-3593-51	05/11/99			X		X			
	RF2-PT-7	99-3593-52	05/11/99			X		X			
	RF2-PT-8	99-3593-53	05/11/99			X		X			
	RF2-PT-9	99-3593-54	05/11/99			X		X			
	RF2-SS-1	99-3622-33	05/11/99	X		X		X			
	RF2-SS-10	99-3622-42	05/11/99	X		X		X			
	RF2-SS-2	99-3622-34	05/11/99	X		X		X			
	RF2-SS-3	99-3622-35	05/11/99	X		X		X			
	RF2-SS-4	99-3622-36	05/11/99	X		X		X			
	RF2-SS-4-99	99-3622-43	05/11/99	X		X		X			
	RF2-SS-5	99-3622-37	05/11/99	X		X		X			
	RF2-SS-6	99-3622-38	05/11/99	X		X		X			
	RF2-SS-7	99-3622-39	05/11/99	X		X		X			

TABLE 3-1

SITES FTIR-38 AND FTIR-40
SUMMARY OF SAMPLES COLLECTED AND ANALYSES PERFORMED, MAY 1999
NATIONAL TRAINING CENTER, FORT IRWIN

				Analyses Requested							
Site	Field Sample ID	Laboratory ID	Date Sampled	Percent Moisture	XRF Lead	Metals	Metals (soluble)	Mercury	SVOCs	Nitrate	Nitrite
	RF2-SS-8	99-3622-40	05/11/99	X		X		X			
	RF2-SS-9	99-3622-41	05/11/99	X		X		X			

Notes:
-99 = Field Duplicate
CNF = confirmation sample
PI = plant tissue
SS = surface soil

TABLE 3-2

SITES FTIR-38 AND FTIR-40
LIST OF METALS ANALYZED IN PLANT TISSUE AND SURFACE SOIL SAMPLES
NATIONAL TRAINING CENTER, FORT IRWIN

SUBSITE		
Site FTIR-38 Area 2	Site FTIR-40 Area 1.1	Site FTIR-40 Area 2
Aluminum	Aluminum	Arsenic
Antimony	Antimony	Cadmium
Arsenic	Arsenic	Lead
Beryllium	Barium	Zinc
Copper	Cadmium	
Lead	Chromium	
Manganese	Copper	
	Lead	

TABLE 4-1

BACKGROUND UPPER TOLERANCE LIMIT (BUTL) SOIL CONCENTRATIONS AND PRELIMINARY REMEDIATION GOALS (PRGs)

Parameter	Calculated BUTL[a]	PRGs
General Chemistry (mg/kg)		
Nitrate/Nitrite	6.32	N/A
Metals (mg/kg)		
Aluminum	23,600	N/A
Antimony	6.34	N/A
Arsenic	9.14	N/A
Barium	175	N/A
Beryllium	1.17	N/A
Cadmium	0.416	N/A
Calcium	23,891[b]	N/A
Chromium	27.7	N/A
Cobalt	12.9	N/A
Copper	28.7	N/A
Iron	23,739[b]	N/A
Lead	7.33	N/A
Magnesium	10,663[b]	N/A
Manganese	361	N/A
Mercury	0.202	N/A
Molybdenum	4.58	N/A
Nickel	29.1	N/A
Potassium	7,382[b]	N/A
Selenium	NA	N/A
Silver	NA	N/A
Sodium	2,372[b]	N/A
Thallium	1.91	N/A
Vanadium	97	N/A
Zinc	51	N/A
SVOCs (mg/kg)		
Bis(2-Ethylexyl)phthalate	N/A	120[c]
Di-n-octylphthalate	N/A	25,000[c]

Notes:

[a] Parsons, 1996

[b] Montgomery Watson, 1996

[c] Industrial Preliminary Remediation Goals (PRGs), (USEPA, 2002)

mg/kg - milligrams per kilogram

NA - not available

N/A - not applicable

TABLE 4-2

SITE FTIR-38 AREA 1
SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Sample ID No.	**38-1-SS-2-2**	**38-1-SS-2-5**
Sample Date	**7/16/1998**	**7/16/1998**
Sample Depth (ft bgs)	**2**	**5**
Parameters		
Metals (mg/kg)		
Aluminum	**30,000**	14,400
Arsenic	ND	**14.6**
Barium	**198**	64.5
Beryllium	**1.6**	0.57
Calcium	**26,500**	**110,000**
Chromium	**33.5**	14.5
Cobalt	**14.1**	7.4
Copper	**49.9**	22.8
Iron	**39,200**	**30,500**
Lead	**105**	**23.2**
Magnesium	**14,400**	**23,500**
Manganese	**801**	**362**
Nickel	28.8	14.4
Potassium	**10,300**	7,170
Sodium	**6,590**	**4,440**
Vanadium	35.6	42.1
Zinc	**149**	**215**

Notes:
ft bgs - feet below ground surface
mg/kg - milligrams per kilograms
Values shown in bold exceed background levels

TABLE 4-3

SITE FTIR-38 AREA 2
PLANT TISSUE AND SURFACE SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 1 of 3)

	SOUTHWEST BERMS							
Sample ID No.	**38-2-PT-1A**	**38-2-PT-2A**	**38-2-PT-3A**	**38-2-PT-3A-99***	**38-2-SS-1A**	**38-2-SS-2**	**38-2-SS-3**	**38-2-SS-3-99***
Sample Date	**5/11/1999**	**5/11/1999**	**5/11/1999**	**5/11/1999**	**5/11/1999**	**5/11/1999**	**5/11/1999**	**5/11/1999**
Parameter								
Metals (mg/kg)								
Aluminum	83.1	107	43.9	108	20,400	**33,100**	**23,900**	**31,700**
Antimony	ND	ND	ND	ND	0.44J	1.2J	1.5J	0.83J
Arsenic	ND	0.1J	ND	ND	8.4	8.0	8.4	8.6
Barium	7.6	9.6	4.0	10.7	168	**186**	**181**	**177**
Cobalt	0.15J	0.16J	0.045J	0.069J	10.6	11.4	11.9	**13.0**
Copper	2.1	2.0	1.6	2.3	**41.0**	**38.0**	**45.8**	**62.2**
Lead	0.14J	0.11J	0.15J	0.37	**52.7**	**29.1**	**157**	**183**
Zinc	6.9	7.3	4.0	4.6	**63.5**	**74.4**	**69.2**	**78.5**

TABLE 4-3

SITE FTIR-38 AREA 2
PLANT TISSUE AND SURFACE SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

	NORTHEAST BERMS						
Sample ID No.	38-2-PT-1	38-2-PT-4	38-2-PT-5	38-2-PT-6	38-2-PT-7	38-2-PT-8	38-2-PT-9
Sample Date	5/10/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999
Parameter							
Metals (mg/kg)							
Aluminum	129	122	111	59.0	63.8	116	38.4
Antimony	0.17J	ND	ND	ND	ND	ND	ND
Arsenic	0.099J	0.13J	0.11J	0.1J	0.15J	ND	ND
Barium	32.2	4.7	8.2	4.5	7.2	5.8	15.0
Cobalt	ND	0.12J	0.073J	0.051J	0.24J	0.12J	0.04J
Copper	4.2	2.3	2.4	2.0	4.4	2.5	1.5
Lead	0.63	0.28J	0.71	0.1J	1.0	0.21J	0.18J
Zinc	5.3	6.8	9.5	6.0	10.8	6.5	6.5

TABLE 4-3

SITE FTIR-38 AREA 2
PLANT TISSUE AND SURFACE SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

	NORTHEAST BERMS						
Sample ID No.	**38-2-SS-1**	**38-2-SS-4**	**38-2-SS-5**	**38-2-SS-6**	**38-2-SS-7**	**38-2-SS-8**	**38-2-SS-9**
Sample Date	**5/10/1999**	**5/11/1999**	**5/11/1999**	**5/11/1999**	**5/11/1999**	**5/11/1999**	**5/11/1999**
Parameter							
Metals (mg/kg)							
Aluminum	13,500	17,600	19,100	19,700	21,800	18,400	11,300
Antimony	ND	0.84J	0.7J	0.82J	1.4J	0.59J	0.6J
Arsenic	4.5	5.2	5.4	5.1	5.1	3.7	3.8
Barium	161	161	172	150	159	115	146
Cobalt	8.3	9.5	9.5	11.0	10	8.2	7.5
Copper	16.3	**30.3**	**42.3**	**40.4**	**52.4**	18.5	16.2
Lead	**7.4**	**51.1**	**103**	**65.0**	**183**	**16.7**	**38.8**
Zinc	40.5	50.5	**54.9**	**60.0**	**59.4**	45.2	36.1

Notes:
J - estimated value
mg/kg - milligrams per kilogram
ND - not detected
PT - plant tissue
SS - surface soil
*99 - indicates that the sample is a field duplicate
Values shown in bold exceed background levels

TABLE 4-4

REFERENCE AREA RF1
PLANT TISSUE AND SURFACE SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 1 of 3)

Sample ID No.	RF1-PT-1	RF1-SS-1	RF1-PT-1A	RF1-SS-1A	RF1-PT-2A	RF1-SS-2A	RF1-PT-3A	RF1-SS-3A
Sample Date	5/10/1999	5/10/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999
Parameter								
Metals (mg/kg)								
Aluminum	17.3	5,670	169	8,430	42.8	7,530	164	9,590
Antimony	ND	ND	0.07J	0.34J	ND	0.3J	0.086J	0.34J
Arsenic	ND	2.8	0.1J	3.8	0.066J	3.3	0.21J	3.7
Barium	10.5	122	8.3	117	6.8	127	12.3	115
Cobalt	ND	5.6	0.11J	6.8	0.85J	6.8	0.15J	7.3
Copper	1.3	8.3	1.6	11.5	1.9	10.3	2.2	12.3
Lead	0.2J	**8.8**	0.26J	**9.8**	0.14J	**9.3**	0.28J	**9.0**
Zinc	1.7	21.7	7.0	29.7	5.7	27.8	7.2	32.3

TABLE 4-4

REFERENCE AREA RF1
PLANT TISSUE AND SURFACE SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Sample ID No. Sample Date	RF1-PT-4A 5/11/1999	RF1-SS-4A 5/11/1999	RF1-PT-4A-99* 5/11/1999	RF1-SS-4A-99* 5/11/1999	RF1-PT-5A 5/11/1999	RF1-SS-5A 5/11/1999	RF1-PT-6A 5/11/1999	RF1-SS-6A 5/11/1999
Parameter								
Metals (mg/kg)								
Aluminum	287	10,500	222	10,400	129	7,670	189	9,780
Antimony	ND	ND	ND	0.25J	ND	0.066J	0.071J	ND
Arsenic	0.29J	3.5	0.28J	3.9	0.14J	3.2	0.14J	3.8
Barium	15.2	123	14.1	119	12.0	112	10.1	125
Cobalt	0.2J	7.9	0.18J	7.9	0.088J	6.8	0.12J	7.4
Copper	2.6	12.5	2.4	12.8	1.8	10.9	1.9	12.4
Lead	0.39	**7.5**	0.37	**7.5**	0.77	**9.4**	0.55	**8.6**
Zinc	7.7	33.1	7.2	33.7	6.1	27.8	6.1	34.1

TABLE 4-4

REFERENCE AREA RF1
PLANT TISSUE AND SURFACE SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 3 of 3)

Sample ID No. **Sample Date**	**RF1-PT-7A** **5/11/1999**	**RF1-SS-7A** **5/11/1999**	**RF1-PT-8A** **5/11/1999**	**RF1-SS-8A** **5/11/1999**	**RF1-PT-9A** **5/11/1999**	**RF1-SS-9A** **5/11/1999**
Parameter						
Metals (mg/kg)						
Aluminum	219	8,100	187	11,400	32.1	12,700
Antimony	ND	ND	ND	0.18J	ND	ND
Arsenic	0.19J	3.6	0.17J	4.0	ND	3.7
Barium	15.2	115	22.8	133	4.1	122
Cobalt	0.16J	6.6	0.13J	8.3	0.03J	8.6
Copper	2.2	11.1	2.1	13.8	1.5	15.7
Lead	0.30	**9.0**	0.31	**8.2**	0.22J	6.7
Zinc	10.3	29.7	6.2	37.0	5.0	37.5

Notes:
J - estimated value
mg/kg - milligrams per kilogram
ND - not detected
PT - plant tissue
SS - surface soil
*99 - indicates that the sample is a field duplicate
Values shown in bold exceed background levels

TABLE 4-5

SITE FTIR-38 AREA 2, NORTHEAST BERMS
XRF SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Berm No.	Sample ID No.	Sample Depth (ft bgs)	Sample Date	XRF Lead (mg/kg)	Field Duplicate XRF Lead (mg/kg)
B1	38-2-SS-28	0	5/13/1999	640	480
	38-2-SS-28-1	1	5/16/1999	1,200	
	38-2-SS-28-2	2	5/17/1999	15	
	38-2-SS-54	0	5/14/1999	490	
	38-2-SS-54-1	1	5/15/1999	2,000	1,700
	38-2-SS-54-2	2	5/16/1999	90	
	38-2-SS-54-3	3	5/19/1999	<10	
	38-2-SS-70	0	5/14/1999	90	
	38-2-SS-70-1	1	5/15/1999	57	
	38-2-SS-70-2	2	5/20/1999	16	
	38-2-SS-80	0	5/15/1999	<10	
	38-2-SS-92	0	5/16/1999	47	
	38-2-SS-114	0	5/17/1999	22	
	38-2-SS-149	0	5/20/1999	24	
	38-2-SS-151	0	5/20/1999	94	
	38-2-SS-175	0	5/21/1999	51	
	38-2-SS-176	0	5/21/1999	78	
	38-2-SS-177	0	5/21/1999	34	
	38-2-SS-178	0	5/21/1999	57	
	38-2-SS-204	0	5/22/1999	41	
	38-2-SS-205	0	5/22/1999	138	
Between B1 and B2	38-2-SS-113	0	5/17/1999	50	
	38-2-SS-113-1	1	5/20/1999	<10	
	38-2-SS-146	0	5/20/1999	86	240
	38-2-SS-179	0	5/21/1999	53	
B2	38-2-SS-27	0	5/13/1999	1,700	
	38-2-SS-27-1	1	5/16/1999	1,700	
	38-2-SS-27-2	2	5/17/1999	53	
	38-2-SS-27-3	3	5/20/1999	100	
	38-2-SS-53	0	5/14/1999	730	
	38-2-SS-53-1	1	5/15/1999	2,500	
	38-2-SS-53-2	2	5/16/1999	510	
	38-2-SS-53-3	3	5/18/1999	16	27
	38-2-SS-69	0	5/14/1999	140	
	38-2-SS-69-1	1	5/15/1999	46	
	38-2-SS-79	0	5/15/1999	73	

TABLE 4-5

SITE FTIR-38 AREA 2, NORTHEAST BERMS
XRF SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Berm No.	Sample ID No.	Sample Depth (ft bgs)	Sample Date	XRF Lead (mg/kg)	Field Duplicate XRF Lead (mg/kg)
	38-2-SS-79-1	1	5/19/1999	<10	
	38-2-SS-91	0	5/16/1999	88	
	38-2-SS-91-1	1	5/18/1999	13	
	38-2-SS-123	0	5/18/1999	15	
	38-2-SS-126	0	5/18/1999	60	
	38-2-SS-126-1	1	5/19/1999	30	
	38-2-SS-141	0	5/19/1999	27	
	38-2-SS-152	0	5/20/1999	68	
	38-2-SS-180	0	5/21/1999	77	
	38-2-SS-181	0	5/21/1999	69	
	38-2-SS-182	0	5/21/1999	32	35
	38-2-SS-206	0	5/22/1999	84	
	38-2-SS-207	0	5/22/1999	89	48
	38-2-SS-208	0	5/22/1999	130	
Between B2 and B3	38-2-SS-112	0	5/17/1999	300	
	38-2-SS-112-1	1	5/19/1999	46	60
	38-2-SS-142	0	5/19/1999	53	
	38-2-SS-142-1	1	5/20/1999	14	19
	38-2-SS-147	0	5/20/1999	36	
	38-2-SS-183	0	5/21/1999	79	
	38-2-SS-184	0	5/21/1999	62	
B3	38-2-SS-26	0	5/13/1999	930	
	38-2-SS-26-1	1	5/16/1999	5,200	
	38-2-SS-26-2	2	5/17/1999	51	
	38-2-SS-26-3	3	5/20/1999	14	
	38-2-SS-52	0	5/14/1999	800	610
	38-2-SS-52-1	1	5/15/1999	340	
	38-2-SS-52-1 5	1.5	5/16/1999	83	
	38-2-SS-52-3	3	5/19/1999	17	
	38-2-SS-68	0	5/14/1999	190	
	38-2-SS-68-1	1	5/15/1999	28	
	38-2-SS-78	0	5/15/1999	90	
	38-2-SS-78-1	1	5/19/1999	28	
	38-2-SS-90	0	5/16/1999	61	
	38-2-SS-90-1	1	5/18/1999	48	
	38-2-SS-122	0	5/18/1999	33	

TABLE 4-5

SITE FTIR-38 AREA 2, NORTHEAST BERMS
XRF SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Berm No.	Sample ID No.	Sample Depth (ft bgs)	Sample Date	XRF Lead (mg/kg)	Field Duplicate XRF Lead (mg/kg)
	38-2-SS-125	0	5/18/1999	120	
	38-2-SS-125-1	1	5/19/1999	18	
	38-2-SS-143	0	5/19/1999	64	
	38-2-SS-153	0	5/20/1999	120	
	38-2-SS-185	0	5/21/1999	94	
	38-2-SS-209	0	5/22/1999	120	
	38-2-SS-210	0	5/22/1999	100	
	38-2-SS-211	0	5/22/1999	92	
	38-2-SS-212	0	5/22/1999	410	
Between B3 and B8	38-2-SS-111	0	5/17/1999	170	
	38-2-SS-111-1	1	5/19/1999	19	
	38-2-SS-145	0	5/19/1999	24	
	38-2-SS-186	0	5/21/1999	66	
	38-2-SS-187	0	5/21/1999	63	
B8	38-2-SS-25	0	5/13/1999	420	
	38-2-SS-25-1	1	5/16/1999	940	
	38-2-SS-25-2	2	5/17/1999	23	
	38-2-SS-51	0	5/14/1999	250	
	38-2-SS-51-1	1	5/15/1999	180	
	38-2-SS-51-1.5	1.5	5/16/1999	130	
	38-2-SS-51-3	3	5/18/1999	<10	16
	38-2-SS-67	0	5/14/1999	110	
	38-2-SS-67-1	1	5/15/1999	<10	
	38-2-SS-67-2	2	5/19/1999	19	
	38-2-SS-77	0	5/15/1999	53	
	38-2-SS-77-1	1	5/19/1999	14	
	38-2-SS-89	0	5/16/1999	74	
	38-2-SS-89-1	1	5/18/1999	15	
	38-2-SS-121	0	5/18/1999	40	
	38-2-SS-124	0	5/18/1999	49	
	38-2-SS-148	0	5/20/1999	48	
	38-2-SS-154	0	5/20/1999	71	
	38-2-SS-188	0	5/21/1999	58	
	38-2-SS-213	0	5/22/1999	73	
	38-2-SS-214	0	5/22/1999	52	
	38-2-SS-215	0	5/22/1999	71	

TABLE 4-5

SITE FTIR-38 AREA 2, NORTHEAST BERMS
XRF SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Berm No.	Sample ID No.	Sample Depth (ft bgs)	Sample Date	XRF Lead (mg/kg)	Field Duplicate XRF Lead (mg/kg)
Between B8 and B9	38-2-SS-110	0	5/17/1999	31	
B9	38-2-SS-24	0	5/13/1999	180	
	38-2-SS-24-1	1	5/16/1999	900	
	38-2-SS-24-2	2	5/17/1999	20	
	38-2-SS-50	0	5/14/1999	230	
	38-2-SS-50-1	1	5/15/1999	180	
	38-2-SS-50-2	2	5/16/1999	460	430
	38-2-SS-50-3	3	5/18/1999	31	
	38-2-SS-66	0	5/14/1999	97	
	38-2-SS-66-1	1	5/15/1999	23	
	38-2-SS-76	0	5/15/1999	34	
	38-2-SS-88	0	5/16/1999	34	
	38-2-SS-155	0	5/20/1999	56	
	38-2-SS-189	0	5/21/1999	180	
	38-2-SS-190	0	5/21/1999	35	58
	38-2-SS-216	0	5/22/1999	62	
Between B9 and B10	38-2-SS-109	0	5/17/1999	26	30
B10	38-2-SS-23	0	5/13/1999	130	
	38-2-SS-23-1	1	5/16/1999	390	
	38-2-SS-23-2	2	5/17/1999	16	
	38-2-SS-49	0	5/14/1999	320	
	38-2-SS-49-1	1	5/15/1999	65	
	38-2-SS-49-2	2	5/16/1999	110	
	38-2-SS-49-3	3	5/18/1999	77	
	38-2-SS-49-4	4	5/20/1999	21	13
	38-2-SS-65	0	5/14/1999	64	
	38-2-SS-65-1	1	5/15/1999	23	
	38-2-SS-75	0	5/15/1999	59	
	38-2-SS-75-1	1	5/19/1999	12	
	38-2-SS-87	0	5/16/1999	22	
	38-2-SS-108	0	5/17/1999	53	48
	38-2-SS-108-1	1	5/19/1999	11	
	38-2-SS-120	0	5/18/1999	28	

TABLE 4-5

SITE FTIR-38 AREA 2, NORTHEAST BERMS
XRF SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Berm No.	Sample ID No.	Sample Depth (ft bgs)	Sample Date	XRF Lead (mg/kg)	Field Duplicate XRF Lead (mg/kg)
	38-2-SS-139	0	5/19/1999	49	
	38-2-SS-140	0	5/19/1999	27	
	38-2-SS-150	0	5/20/1999	31	
	38-2-SS-156	0	5/20/1999	82	
	38-2-SS-191	0	5/21/1999	370	
	38-2-SS-192	0	5/21/1999	88	
	38-2-SS-217	0	5/22/1999	60	
	38-2-SS-218	0	5/22/1999	140	
	38-2-SS-219	0	5/22/1999	49	
B13	38-2-SS-19	0	5/13/1999	10	
	38-2-SS-45	0	5/14/1999	17	
	38-2-SS-93	0	5/16/1999	17	
	38-2-SS-94	0	5/16/1999	25	
	38-2-SS-129	0	5/18/1999	12	
B14	38-2-SS-20	0	5/13/1999	12	
	38-2-SS-46	0	5/14/1999	25	
	38-2-SS-95	0	5/16/1999	<10	
	38-2-SS-96	0	5/16/1999	28	
	38-2-SS-130	0	5/18/1999	23	
B15	38-2-SS-21	0	5/13/1999	28	
	38-2-SS-47	0	5/14/1999	22	
	38-2-SS-97	0	5/16/1999	15	
	38-2-SS-98	0	5/16/1999	22	
	38-2-SS-131	0	5/18/1999	14	
B16	38-2-SS-22	0	5/13/1999	29	11
	38-2-SS-48	0	5/14/1999	28	
	38-2-SS-99	0	5/16/1999	24	
	38-2-SS-100	0	5/16/1999	17	
	38-2-SS-132	0	5/18/1999	17	

Notes:
ft bgs - feet below ground surface
mg/kg - milligrams per kilogram
XRF - x-ray fluorescence

TABLE 4-6

SITE FTIR-38 AREA 2, SOUTHWEST BERMS
XRF SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 1 of 4)

Berm No.	Sample ID No.	Sample Depth (ft bgs)	Sample Date	XRF Lead (mg/kg)	Field Duplicate XRF Lead (mg/kg)
B4	38-2-SS-11	0	5/13/1999	600	
	38-2-SS-11-1	1	5/13/1999	1,700	
	38-2-SS-11-2	2	5/16/1999	<10	230
	38-2-SS-11-3	3	5/19/1999	23	
	38-2-SS-37	0	5/14/1999	2,100	
	38-2-SS-37-1	1	5/15/1999	580	
	38-2-SS-37-2	2	5/16/1999	160	
	38-2-SS-37-3	3	5/18/1999	320	30
	38-2-SS-37-4	4	5/19/1999	41	80
	38-2-SS-37-5	5	5/19/1999	44	
	38-2-SS-59	0	5/14/1999	130	86
	38-2-SS-59-1	1	5/15/1999	20	
	38-2-SS-71	0	5/15/1999	38	
	38-2-SS-81	0	5/16/1999	97	
	38-2-SS-81-1	1	5/18/1999	22	
	38-2-SS-101	0	5/17/1999	12	
	38-2-SS-115	0	5/18/1999	67	
	38-2-SS-115-1	1	5/19/1999	120	
	38-2-SS-115-2	2	5/19/1999	19	
	38-2-SS-134	0	5/19/1999	15	
	38-2-SS-157	0	5/20/1999	76	
	38-2-SS-173	0	5/21/1999	36	
	38-2-SS-174	0	5/21/1999	39	
	38-2-SS-202	0	5/22/1999	130	
	38-2-SS-203	0	5/22/1999	35	
B5	38-2-SS-14	0	5/13/1999	1,400	
	38-2-SS-14-1	1	5/13/1999	160	
	38-2-SS-14-2	2	5/16/1999	22	
	38-2-SS-40	0	5/14/1999	1,200	
	38-2-SS-40-1	1	5/15/1999	71	
	38-2-SS-40-2	2	5/16/1999	30	
	38-2-SS-62	0	5/14/1999	65	
	38-2-SS-62-1	1	5/15/1999	50	
	38-2-SS-62-2	2	5/19/1999	14	
	38-2-SS-74	0	5/15/1999	46	
	38-2-SS-84	0	5/16/1999	59	46
	38-2-SS-84-1	1	5/18/1999	15	
	38-2-SS-118	0	5/18/1999	53	
	38-2-SS-118-1	1	5/19/1999	17	
	38-2-SS-137	0	5/19/1999	21	

TABLE 4-6

SITE FTIR-38 AREA 2, SOUTHWEST BERMS
XRF SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Berm No.	Sample ID No.	Sample Depth (ft bgs)	Sample Date	XRF Lead (mg/kg)	Field Duplicate XRF Lead (mg/kg)
	38-2-SS-160	0	5/20/1999	120	
	38-2-SS-161	0	5/21/1999	43	
	38-2-SS-162	0	5/21/1999	40	
	38-2-SS-163	0	5/21/1999	34	43
	38-2-SS-164	0	5/21/1999	52	
	38-2-SS-193	0	5/22/1999	73	
	38-2-SS-194	0	5/22/1999	100	130
Between B5 and B6	38-2-SS-104	0	5/17/1999	43	41
B6	38-2-SS-13	0	5/13/1999	720	
	38-2-SS-13-1	1	5/13/1999	200	
	38-2-SS-13-2	2	5/16/1999	<10	
	38-2-SS-39	0	5/14/1999	1,900	
	38-2-SS-39-1	1	5/15/1999	670	
	38-2-SS-39-2	2	5/16/1999	77	
	38-2-SS-39-3	3	5/19/1999	13	
	38-2-SS-61	0	5/14/1999	61	
	38-2-SS-61-1	1	5/15/1999	29	
	38-2-SS-73	0	5/15/1999	<10	
	38-2-SS-73-1	1	5/19/1999	14	
	38-2-SS-83	0	5/16/1999	270	
	38-2-SS-83-1	1	5/18/1999	23	
	38-2-SS-117	0	5/18/1999	28	
	38-2-SS-144	0	5/19/1999	45	
	38-2-SS-159	0	5/20/1999	91	
	38-2-SS-165	0	5/21/1999	42	
	38-2-SS-166	0	5/21/1999	10	
	38-2-SS-167	0	5/21/1999	98	
	38-2-SS-168	0	5/21/1999	210	
	38-2-SS-195	0	5/22/1999	61	
	38-2-SS-196	0	5/22/1999	80	
	38-2-SS-197	0	5/22/1999	39	
Between B6 and B7	38-2-SS-103	0	5/17/1999	57	47
	38-2-SS-103-1	1	5/19/1999	<10	25
	38-2-SS-135	0	5/19/1999	16	

TABLE 4-6

SITE FTIR-38 AREA 2, SOUTHWEST BERMS
XRF SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Berm No.	Sample ID No.	Sample Depth (ft bgs)	Sample Date	XRF Lead (mg/kg)	Field Duplicate XRF Lead (mg/kg)
B7	38-2-SS-12	0	5/13/1999	1,000	
	38-2-SS-12-1	1	5/13/1999	1,300	
	38-2-SS-12-2	2	5/16/1999	70	
	38-2-SS-12-3	3	5/19/1999	84	
	38-2-SS-12-4	4	5/19/1999	57	31
	38-2-SS-12-5	5	5/20/1999	22	
	38-2-SS-38	0	5/14/1999	2,500	
	38-2-SS-38-1	1	5/15/1999	710	540
	38-2-SS-38-2	2	5/16/1999	230	
	38-2-SS-38-3	3	5/18/1999	17	
	38-2-SS-60	0	5/14/1999	72	
	38-2-SS-60-1	1	5/15/1999	19	17
	38-2-SS-72	0	5/15/1999	21	
	38-2-SS-82	0	5/16/1999	170	
	38-2-SS-82-1	1	5/18/1999	25	15
	38-2-SS-116	0	5/18/1999	180	
	38-2-SS-116-1	1	5/19/1999	33	20
	38-2-SS-136	0	5/19/1999	33	
	38-2-SS-158	0	5/20/1999	63	
	38-2-SS-169	0	5/21/1999	110	
	38-2-SS-170	0	5/21/1999	62	
	38-2-SS-171	0	5/21/1999	43	
	38-2-SS-172	0	5/21/1999	71	89
	38-2-SS-198	0	5/22/1999	34	
	38-2-SS-199	0	5/22/1999	47	
	38-2-SS-200	0	5/22/1999	100	
	38-2-SS-201	0	5/22/1999	150	68
Between B7 and B4	38-2-SS-102	0	5/17/1999	40	
B11	38-2-SS-17	0	5/13/1999	<10	
	38-2-SS-35	0	5/13/1999	<10	
	38-2-SS-36	0	5/13/1999	15	
	38-2-SS-43	0	5/14/1999	16	
	38-2-SS-128	0	5/18/1999	11	
B12	38-2-SS-18	0	5/13/1999	<10	
	38-2-SS-33	0	5/13/1999	27	19
	38-2-SS-34	0	5/13/1999	12	
	38-2-SS-44	0	5/14/1999	34	
	38-2-SS-127	0	5/18/1999	32	

TABLE 4-6

SITE FTIR-38 AREA 2, SOUTHWEST BERMS
XRF SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Berm No.	Sample ID No.	Sample Depth (ft bgs)	Sample Date	XRF Lead (mg/kg)	Field Duplicate XRF Lead (mg/kg)
B17	38-2-SS-16	0	5/13/1999	85	
	38-2-SS-16-1	1	5/16/1999	34	
	38-2-SS-31	0	5/13/1999	70	
	38-2-SS-31-1	1	5/16/1999	190	
	38-2-SS-31-2	2	5/18/1999	33	
	38-2-SS-32	0	5/13/1999	25	
	38-2-SS-42	0	5/14/1999	100	
	38-2-SS-42-1	1	5/15/1999	45	
	38-2-SS-64	0	5/14/1999	22	
	38-2-SS-86	0	5/16/1999	27	
	38-2-SS-107	0	5/17/1999	16	<10
Between B17 and B18	38-2-SS-106	0	5/17/1999	20	24
B18	38-2-SS-15	0	5/13/1999	24	
	38-2-SS-29	0	5/13/1999	26	
	38-2-SS-30	0	5/13/1999	140	
	38-2-SS-30-1	1	5/15/1999	57	
	38-2-SS-30-2	2	5/19/1999	14	
	38-2-SS-41	0	5/14/1999	60	
	38-2-SS-41-1	1	5/15/1999	16	
	38-2-SS-63	0	5/14/1999	45	
	38-2-SS-85	0	5/16/1999	61	
	38-2-SS-85-1	1	5/18/1999	16	
	38-2-SS-119	0	5/18/1999	34	
Between B18 and B5	38-2-SS-105	0	5/17/1999	<10	67
	38-2-SS-105-1	1	5/19/1999	25	
	38-2-SS-138	0	5/19/1999	17	

Notes:

ft bgs - feet below ground surface

mg/kg - milligrams per kilogram

XRF - x-ray fluorescence

TABLE 4-7

SITE FTIR-38 AREA 2, OFF-SITE BERMS
XRF SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Berm No.	Sample ID No.	Sample Date	XRF Lead (mg/kg)
B19	38-2-SS-58	5/14/1999	12
B20	38-2-SS-57	5/14/1999	10
B21	38-2-SS-56	5/14/1999	17
B22	38-2-SS-55	5/14/1999	16

Notes:

All samples were collected from the surface

mg/kg - milligrams per kilogram

XRF - x-ray fluorescence

TABLE 4-8

SITE FTIR-40 AREA 1.1
PLANT TISSUE AND SURFACE SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 1 of 2)

Sample ID No.	40-1-PT-1	40-1-PT-2	40-1-PT-3	40-1-PT-3-99	40-1-PT-4	40-1-PT-5	40-1-PT-6	40-1-PT-7	40-1-PT-8	40-1-PT-9	40-1-PT-10
Sample Date	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999
Parameters											
Metals (mg/kg)											
Aluminum	33.6	30.5	29.2	24.0	28.9	40.0	26.1	32.3	20.2	52.5	27.1
Antimony	ND	0.064J	ND	ND	ND	ND	ND	ND	0.07J	ND	ND
Arsenic	0.087J	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.069J
Barium	15.7	7.6	15.8	16.4	27.8	14.1	19.5	18.0	9.7	17.6	21.0
Cadmium	0.072J	**0.69**	**0.48J**	0.05J	0.04J	0.36	0.045J	0.066J	0.21	0.033J	0.06J
Chromium	0.91	1.6	0.82	1.1	1.1	1.8	0.80	1.9	1.1	0.53	0.83
Cobalt	0.052J	0.14J	0.025J	ND	ND	0.052J	ND	ND	0.026J	0.027J	ND
Copper	3.3	6.5	1.8	1.3	1.7	4.6	2.0	1.6	2.8	2.1	1.8
Lead	0.2J	0.61	0.06J	0.15J	0.13J	0.52	0.087J	0.18J	0.3J	0.26J	0.095J
Manganese	6.6	23.8	22.1	5.8	9.4	12.8	13.2	27.9	6.5	5.4	17.4
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1
Nickel	0.48	2.0	0.22J	0.18J	0.13J	0.35	0.13J	0.15J	0.59	0.13J	0.2J
Selenium	0.42J	0.3J	0.26J	0.26J	0.18J	0.51	0.33J	0.32J	0.21J	0.34J	0.38J
Silver	ND	0.03J	0.024J	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	7.4	**53.3**	7.1	3.8	2.4	19.7	3.4	4.3	11.0	4.8	2.8

TABLE 4-8

SITE FTIR-40 AREA 1.1
PLANT TISSUE AND SURFACE SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 2 of 2)

Sample ID No.	40-1-SS-1	40-1-SS-2	40-1-SS-3	40-1-SS-3-99	40-1-SS-4	40-1-SS-5	40-1-SS-6	40-1-SS-7	40-1-SS-8	40-1-SS-9	40-1-SS-10
Sample Date	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999
Parameters											
Metals (mg/kg)											
Aluminum	12,400	11,500	12,200	11,600	12,300	9,600	11,300	12,700	13,600	8,770	13,300
Antimony	ND	0.97J	ND	ND	ND	ND	ND	ND	1.8J	ND	ND
Arsenic	5.2	8.4	4.2	3.4	4.2	3.8	3.5	5.0	4.3	2.8	4.9
Barium	**178**	**205**	156	152	154	153	144	159	**241**	131	**178**
Cadmium	ND	**0.93**	0.26J	0.19J	ND	0.31J	ND	0.22J	**3.5**	0.21J	0.21J
Chromium	12.1	13.2	11.3	11.1	10.2	9.1	10.1	12.3	15.3	7.7	13.6
Cobalt	7.8	8.2	7.5	7.7	6.9	6.8	6.7	8.0	7.8	5.4	8.8
Copper	18.0	**45.9**	18.0	17.4	13.2	18.1	14.7	23.8	**127**	22.9	16.0
Lead	**10.4**	**116**	**13.0**	**10.2**	**11.2**	**12.5**	**8.9**	**12.2**	**124**	**7.8**	**10.4**
Manganese	**433**	**368**	**417**	**403**	**366**	**401**	**386**	**458**	**468**	290	**505**
Mercury	0.11	0.092J	0.13	0.10	0.11	0.11	0.083J	0.072J	0.87	0.09J	0.11
Nickel	11.0	14.1	10.2	10.1	9.2	7.8	8.8	11.3	13.0	8.0	11.6
Selenium	0.58J	ND	0.98J	0.42J	0.51J	ND	ND	0.52J	ND	ND	0.54J
Silver	ND	2.9	2.4	1.5J	0.83J	1.7J	ND	ND	41.3	0.92J	0.73J
Zinc	**52.5**	**1,060**	**61.0**	**53.9**	50.9	**55.2**	43.7	**65.6**	**306**	47.0	**54.1**

Notes:

J - estimated value

mg/kg - milligrams per kilogram

ND - not detected

PT - plant tissue

SS - surface soil

*99 - indicates that the sample is a field duplicate

Values shown in bold exceed background levels

TABLE 4-9

REFERENCE AREA RF2
PLANT TISSUE AND SURFACE SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Sample ID No.	RF2-PT-1	RF2-PT-2	RF2-PT-3	RF2-PT-4	RF2-PT-4-99	RF2-PT-5	RF2-PT-6	RF2-PT-7	RF2-PT-8	RF2-PT-9	RF2-PT-10
Sample Date	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999	5/11/1999
Parameter											
Metals (mg/kg)											
Aluminum	48.5	21.7	59.3	46.1	48.0	28.6	30.3	57.2	38.0	36.7	60.8
Antimony	0.11J	ND	0.072J	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND	0.11J	ND	ND	0.066J	ND	ND	0.11J
Barium	37.0	19.5	24.7	30.5	28.3	8.2	27.7	34.0	24.1	37.5	25.2
Cadmium	0.072J	0.034J	0.032J	0.041J	0.036J	0.033J	0.031J	0.045J	0.035J	0.036J	0.039J
Chromium	2.3	0.77	0.87	1.3	1.2	0.91	0.62	1.2	0.91	1.1	0.71
Cobalt	0.035J	ND	0.04J	0.022J	0.042J	ND	ND	0.033J	ND	ND	0.033J
Copper	1.8	1.4	1.5	1.6	2.0	1.1	1.5	2.8	1.3	1.9	1.7
Lead	0.2J	0.12J	0.19J	0.63	0.26J	0.11J	0.059J	0.28J	0.15J	0.11J	0.23J
Manganese	27.0	17.5	10.8	23.7	17.1	16.1	17.0	18.5	14.6	11.2	11.4
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	0.39	0.12J	0.15J	0.33	0.46	0.22J	0.15J	0.21J	0.19J	0.15J	0.24J
Selenium	0.25J	0.31J	0.25J	0.27J	0.28J	0.39J	0.34J	0.3J	0.2J	0.34J	0.36J
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	4.0	2.2	2.3	3.2	4.2	1.7	2.5	3.7	3.5	3.0	2.7

TABLE 4-9

REFERENCE AREA RF2
PLANT TISSUE AND SURFACE SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 2 of 2)

Sample ID No. Sample Date	RF2-SS-1 5/11/1999	RF2-SS-2 5/11/1999	RF2-SS-3 5/11/1999	RF2-SS-4 5/11/1999	RF2-SS-4-99 5/11/1999	RF2-SS-5 5/11/1999	RF2-SS-6 5/11/1999	RF2-SS-7 5/11/1999	RF2-SS-8 5/11/1999	RF2-SS-9 5/11/1999	RF2-SS-10 5/11/1999
Parameter											
Metals (mg/kg)											
Aluminum	12,300	11,300	12,100	11,700	8,590	14,000	10,900	11,100	12,600	9,520	15,200
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.65J
Arsenic	6.6	6.6	6.6	7.9	7.0	7.3	5.4	6.3	7.8	7.2	10.7
Barium	180	140	153	177	146	121	151	194	183	150	192
Cadmium	ND	ND	ND	0.19J	ND	ND	ND	ND	ND	ND	ND
Chromium	11.2	11.8	11.7	11.6	8.2	16.2	10.4	10.6	12.1	9.3	14.6
Cobalt	7.5	7.6	8.1	7.8	6.3	9.8	7.4	7.2	8.4	6.8	9.4
Copper	16.0	14.4	16.3	17.8	11.7	19.1	13.9	15.0	17.8	13.8	21.6
Lead	11.0	10.2	9.7	13.4	8.4	11.0	9.9	12.7	12.0	9.7	11.6
Manganese	346	359	374	376	324	378	392	372	383	348	422
Mercury	0.11	0.13	0.16	0.12	0.13	0.11	0.12	0.11	0.12	0.10	0.11
Nickel	11.1	11.0	12.8	12.0	9.5	13.9	10.4	10.8	12.6	9.6	16.0
Selenium	0.93J	0.62J	0.44J	0.59J	ND	ND	0.64J	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	45.8	42.6	46.7	52.6	35.9	53.7	41.2	47.4	54.1	38.4	64.0

Notes:

J - estimated value

mg/kg - milligrams per kilogram

ND - not detected

PT - plant tissue

SS - surface soil

*99 - indicates that the sample is a field duplicate

Values shown in bold exceed background levels

TABLE 4-10

SITE FTIR-40 AREA 2
PLANT TISSUE AND SURFACE SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 1 of 2)

Parameters	40-2-PT-1 5/10/1999	40-2-PT-2 5/10/1999	40-2-PT-2-99 5/10/1999	40-2-PT-3 5/10/1999	40-2-PT-4 5/10/1999	40-2-PT-5 5/10/1999	40-2-PT-6 5/11/1999	40-2-PT-7 5/11/1999	40-2-PT-8 5/11/1999	40-2-PT-9 5/11/1999	40-2-PT-10 5/11/1999
Metals (mg/kg)											
Arsenic	ND	ND	ND	ND	0.12J	ND	0.15J	ND	ND	ND	ND
Cadmium	0.10	0.22	0.25	0.13J	0.095J	0.081J	0.081J	0.058J	0.11J	0.12J	0.049J
Lead	0.51	0.40	0.35	0.50	0.43	0.23J	0.28J	0.13J	0.17J	0.29J	0.14J
Zinc	5.7	19.7	21.8	15.4	10.9	16.7	5.9	2.7	4.5	4.3	3.0

TABLE 4-10

SITE FTIR-40 AREA 2
PLANT TISSUE AND SURFACE SOIL SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Parameters	40-2-SS-1 5/10/1999	40-2-SS-2 5/10/1999	40-2-SS-2-99 5/10/1999	40-2-SS-3 5/10/1999	40-2-SS-4 5/10/1999	40-2-SS-5 5/10/1999	40-2-SS-6 5/11/1999	40-2-SS-7 5/11/1999	40-2-SS-8 5/11/1999	40-2-SS-9 5/11/1999	40-2-SS-10 5/11/1999
Metals (mg/kg)											
Arsenic	8.7	8.9	**10.9**	**9.6**	**9.4**	8.4	**9.2**	9.0	8.0	**10**	**9.2**
Cadmium	0.2J	0.24	0.31	**0.50**	0.34	0.15J	0.25	0.21	0.27	0.32J	0.26J
Lead	**11.0**	**13.3**	**17.2**	**259**	**30.1**	**9.5**	**11.6**	**9.4**	**12.9**	**12.4**	**10.5**
Zinc	48.1	50.3	**70.3**	**213**	**74.5**	49.8	**52.8**	45.5	**72.4**	**55.3**	**53.0**

Notes:
J - estimated value
mg/kg - milligrams per kilogram
ND - not detected
PT - plant tissue
SS - surface soil
*99 - indicates that the sample is a field duplicate
Values shown in bold exceed background levels

TABLE 4-11

SITE FTIR-40 AREA 2
SOIL BORING SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 1 of 3)

Sample ID No.	40-2-SB-1-2.5	40-2-SB-1-5.0	40-2-SB-1-5-99	40-2-SB-1-10.0	40-2-SB-2-5.0	40-2-SB-2-10.0
Sample Date	5/12/1999	5/12/1999	5/12/1999	5/12/1999	5/12/1999	5/12/1999
Sample Depth (ft bgs)	2.5	5	5	10	5	10
Parameter						
General Chemistry (mg/kg)						
Nitrate	**13**	**238**	**263**	**158**	**247**	**141**
Nitrite	0 1	0.07J	0 06J	0 1	0 24	0 2
Metals (mg/kg)						
Aluminum	12,600	10,400	11,600	12,300	11,900	8,950
Antimony	ND	ND	ND	ND	ND	0.32J
Arsenic	**10**	7.4	**11.4**	8.7	**9.5**	9.0
Barium	**177**	113	110	150	169	149
Cadmium	0 22J	ND	0 21J	ND	ND	ND
Chromium	14.8	14.0	13.0	16.4	16.1	12.5
Cobalt	8.7	6.9	7.7	7.4	7.7	5.8
Copper	19 4	12.7	18.1	15.6	17.0	10
Lead	**11.2**	5.5	**8.6**	6.7	**7.7**	4.7
Manganese	**370**	238	250	296	313	237
Mercury	0.082J	0.072J	0.057J	0.073J	0.071J	0 072J
Nickel	14.8	11.3	14.6	12.6	13.6	9.7
Selenium	0.84J	ND	ND	ND	0.65J	ND
Silver	ND	ND	ND	ND	ND	ND
Zinc	**52.6**	38.5	47 4	41.8	49 2	30 6
Beryllium	0.28J	ND	0 34J	0 15J	0.41J	0.11J
Calcium	13,200	18,300	21,400	**26,900**	12,800	**40,300**
Iron	20,500	17,600	21,900	20,400	21,000	14,400
Magnesium	4,810	3,990	4,210	4,660	4,890	3,750
Molybdenum	0.95	0 54J	0.6J	0 55J	0.46J	ND
Potassium	2,200	1,900	2,140	2,310	2,500	1,750
Sodium	205	365	409	495	436	433
Thallium	ND	ND	ND	ND	ND	ND
Vanadium	30 9	23 7	29 0	26 4	31.4	21 0
SVOCs (µg/kg)						
Bis(2-ethylhexyl) phthalate	410	245	77J	322	235	77J
Di-n-octylphthalate	333	205	ND	256	196	57J

TABLE 4-11

SITE FTIR-40 AREA 2
SOIL BORING SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 2 of 3)

Sample ID No.	40-2-SB-2-10-99	40-2-SB-3-2.5	40-2-SB-3-5.0	40-2-SB-3-10.0	40-2-SB-4-2.5
Sample Date	5/12/1999	5/12/1999	5/12/1999	5/12/1999	5/12/1999
Sample Depth (ft bgs)	10	2.5	5	10	2.5
Parameter					
General Chemistry (mg/kg)					
Nitrate	**134**	7	6	**13**	5J
Nitrite	0.2	0.08J	0.1	0.1	0.28
Metals (mg/kg)					
Aluminum	7,310	10,300	9,090	10,700	10,800
Antimony	ND	ND	ND	0.48J	ND
Arsenic	8.0	**10**	8.3	8.6	**9.2**
Barium	173	170	157	**195**	132
Cadmium	ND	0.22J	ND	ND	ND
Chromium	8.8	14.0	13.2	18.6	10.9
Cobalt	5.4	7.5	6.2	6.7	6.6
Copper	9.9	16.2	13.2	13.2	13.9
Lead	4.7	**8.3**	**8.0**	6.9	**8.5**
Manganese	249	296	260	247	293
Mercury	0.086J	0.096J	0.08J	0.077J	0.086J
Nickel	8.1	14.1	10.7	11.2	11.6
Selenium	0.64J	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND
Zinc	24.0	**51.8**	41.4	38.6	46.4
Beryllium	0.14J	0.48J	0.34J	0.28J	0.84
Calcium	**49,800**	15,800	15,700	**31,600**	12,400
Iron	12,000	19,200	16,400	16,600	16,800
Magnesium	3,410	4,260	3,680	4,200	4,550
Molybdenum	ND	0.59J	0.75J	1.2	0.44J
Potassium	1,430	1,850	1,750	2,010	1,850
Sodium	468	330	278	776	646
Thallium	ND	ND	ND	0.65J	ND
Vanadium	17.0	27.9	23.9	24.9	25.8
SVOCs (µg/kg)					
Bis(2-ethylhexyl) phthalate	ND	ND	96	95	ND
Di-n-octylphthalate	ND	ND	88	ND	ND

TABLE 4-11

SITE FTIR-40 AREA 2
SOIL BORING SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 3 of 3)

Sample ID No.	40-2-SB-4-5.0	40-2-SB-4-10.0	40-2-SB-5-2 5	40-2-SB-5-5.0	40-2-SB-5-10.0
Sample Date	5/12/1999	5/12/1999	5/12/1999	5/12/1999	5/12/1999
Sample Depth (ft bgs)	5	10	2.5	5	10
Parameter					
General Chemistry (mg/kg)					
Nitrate	6	**33**	6	6	**17**
Nitrite	0 2	0 27	0 24	0 24	0 23
Metals (mg/kg)					
Aluminum	11,500	10,000	11,300	12,400	10,800
Antimony	ND	ND	0 35J	ND	ND
Arsenic	9.1	7.9	**10.5**	**10.9**	9
Barium	172	**195**	**194**	**176**	**187**
Cadmium	0 21J	ND	0 27J	0 37J	ND
Chromium	13 9	15.7	16.3	15.6	9 2
Cobalt	7.4	6.2	9.3	8.0	5.9
Copper	16.3	12.1	16.9	18.7	10.0
Lead	**8.2**	**8.1**	**9.7**	**8.5**	5.1
Manganese	324	257	**502**	331	252
Mercury	0.081J	0.093J	0 12	0.11	0.11
Nickel	12.7	10.5	14.1	13.7	8.6
Selenium	0.53J	ND	ND	0.52J	ND
Silver	ND	ND	ND	ND	ND
Zinc	48.7	36 1	50.7	49.5	31.2
Beryllium	0 4J	0.21J	0.37J	0.53J	ND
Calcium	14,700	**30,100**	16 600	19,000	**47,800**
Iron	19,100	16,100	19,300	21,400	13,300
Magnesium	4,940	4,090	4,890	4,710	4,830
Molybdenum	0 65J	0.47	0 55J	0.89	0 43J
Potassium	2,220	1,850	2 220	2,280	2 060
Sodium	257	655	161J	493	1,530
Thallium	ND	ND	ND	ND	ND
Vanadium	28 6	23 1	30 1	30.7	20 3
SVOCs (μg/kg)					
Bis(2-ethylhexyl) phthalate	110	170	140J	150J	79J
Di-n-octylphthalate	ND	ND	99J	120J	71J

Notes:
ft bgs - feet below ground surface
J - estimated value
μg/kg - micrograms per kilograms
mg/kg - milligrams per kilograms
ND - not detected
SVOCs - semi-volatile organic compounds
Values shown in bold exceed background levels

TABLE 6-1

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR SURFACE SOILS[a]
SITE FTIR-38 AREA 1
NATIONAL TRAINING CENTER, FORT IRWIN

	Soil Concentration (mg/kg)					Number of		Detection	BUTL [g]	
Constituent	Maximum [b]		Minimum [c]		Mean [d]	Samples [e]	Detections [f]	Frequency	(mg/kg)	COPC [h]
Inorganics										
Aluminum	30,900		25,100		28,717	5	5	100%	23,600	Yes
Antimony	0.77	J	0.5 [i]	nd	0.6	5	4	80%	6.34	No
Arsenic	15.5		13		14	5	5	100%	9.14	Yes
Barium	244		219		233	5	5	100%	175	Yes
Beryllium	1.7	J	1.4	J	1.5	5	5	100%	1.17	Yes
Cadmium	1.1	J	0.26	J	0.598	5	5	100%	0.416	Yes
Calcium	41,800		24,100		28,633	5	5	100%	na	No [j]
Chromium	29.9	J	24.5	J	26.8	5	5	100%	27.7	Yes
Cobalt	15.9	J	13.8	J	15.1	5	5	100%	12.9	Yes
Copper	79.8		41.3		49.0	5	5	100%	28.7	Yes
Iron	30,800		27,800		29,367	5	5	100%	na	No [j]
Lead	190		36.5		110	5	5	100%	7.33	Yes
Magnesium	19,600		14,400		16,367	5	5	100%	na	No [j]
Manganese	765		715		739	5	5	100%	361	Yes
Molybdenum	5.5		0.980		2.3	5	5	100%	4.58	Yes
Potassium	10,500		8,640		9,690	5	5	100%	na	No [j]
Sodium	12,300		4,210		8,248	5	5	100%	na	No [j]
Vanadium	38.9		32.8		34.8	5	5	100%	97	No
Zinc	177		97.2		118	5	5	100%	51	Yes

Notes:
[a] Surface soil depth equal to 0 - 1 ft bgs.
[b] Maximum detected concentration of original or duplicate soil samples (0 - 1 ft bgs).
[c] Minimum concentration of original or duplicate samples (0 - 1 ft bgs).
[d] The arithmetic mean soil concentration for soil samples collected in the interval 0 - 1 ft bgs.
[e] Total number of soil samples collected in the interval 0 - 1 ft bgs (excludes duplicate samples).
[f] Total number of detections in soil samples collected in the interval 0 - 1 ft bgs (excludes duplicate samples).
[g] Background upper tolerance limit for Fort Irwin Soils. Source: Parsons Engineering Science, Inc., 1996.
[h] Constituent is considered a chemical of potential concern (COPC) if maximum concentration exceeds BUTL.
[i] Minimum concentration is a non-detect value and is assumed to be one-half the detection limit.
[j] Analyte eliminated as a COPC based on its role as an essential dietary nutrient (refer to Section 6.2.4).

J - estimated valuee
mg/kg - milligrams per kilogram
na - not applicable
nd - not detected

TABLE 6-2

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR SUBSURFACE SOILS[a]
SITE FTIR-38 AREA 1
NATIONAL TRAINING CENTER, FORT IRWIN

	Soil Concentration (mg/kg)			Number of		Detection	BUTL [g]	
Constituent	Maximum [b]	Minimum [c]	Mean [d]	Samples [e]	Detections [f]	Frequency	(mg/kg)	COPC [h]
Inorganics								
Aluminum	30,000	14,400	22,200	2	2	100%	23,600	Yes
Barium	198	64.5	131	2	2	100%	175	Yes
Beryllium	1.6	0.57	1.1	2	2	100%	1.17	Yes
Calcium	110,000	26,500	68,250	2	2	100%	na	No[i]
Chromium	33.5	14.5	24.0	2	2	100%	27.7	Yes
Cobalt	14.1	7.4	10.8	2	2	100%	12.9	Yes
Copper	49.9	22.8	36.4	2	2	100%	28.7	Yes
Iron	39,200	30,500	34,850	2	2	100%	na	No[i]
Lead	105	23.2	64.1	2	2	100%	7.33	Yes
Magnesium	23,500	14,400	18,950	2	2	100%	na	No[i]
Manganese	801	362	582	2	2	100%	361	Yes
Nickel	28.8	14.4	21.6	2	2	100%	29.1	No
Potassium	10,300	7,170	8,735	2	2	100%	na	No[i]
Sodium	6,590	4,440	5,515	2	2	100%	na	No[i]
Vanadium	421	35.6	228	2	2	100%	97	Yes
Zinc	215	149	182	2	2	100%	51	Yes

Notes:

[a] Soil depth equal to >1 - 10 ft bgs.

[b] Maximum detected concentration of original or duplicate soil samples (>1 - 10 ft bgs).

[c] Minimum concentration of original or duplicate samples (>1 - 10 ft bgs).

[d] The arithmetic mean soil concentration for soil samples collected in the interval >1 - 10 ft bgs.

[e] Total number of soil samples collected in the interval >1 - 10 ft bgs (excludes duplicate samples).

[f] Total number of detections in soil samples collected in the interval >1 - 10 ft bgs (excludes duplicate samples).

[g] Background upper tolerance limit for Fort Irwin Soils. Source: Parsons Engineering Science, Inc., 1996.

[h] Constituent is considered a chemical of potential concern (COPC) if maximum concentration exceeds BUTL.

[i] Analyte eliminated as a COPC based on its role as an essential dietary nutrient (refer to Section 6.2.4).

J - estimated valuee

mg/kg - milligrams per kilogram

na - not applicable

nd - not detected

TABLE 6-3

SUMMARY OF CHEMICALS OF POTENTIAL CONCERN[a]
SITE FTIR-38 AREA 1
NATIONAL TRAINING CENTER, FORT IRWIN

Surface Soils [b]	Subsurface Soils [c]
Inorganics	**Inorganics**
Aluminum	Aluminum
Arsenic	Barium
Barium	Beryllium
Beryllium	Chromium
Cadmium	Cobalt
Chromium	Copper
Cobalt	Lead
Copper	Manganese
Lead	Vanadium
Manganese	Zinc
Molybdenum	
Zinc	

Notes:
[a] Refer to Tables 6-1 and 6-2 for COPC selection
[b] Surface soil depth equal to 0 - 1 ft bgs
[c] Subsurface soil depth equal to >1 ft bgs
COPC - Chemical of potential concern

TABLE 6-4

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR SURFACE SOILS[a]
SITE FTIR-38 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

Constituent	Soil Concentration (mg/kg)					Number of		Detection	BUTL[g]	
	Maximum[b]		Minimum[c]		Mean[d]	Samples[e]	Detections[f]	Frequency	(mg/kg)	COPC[h]
Inorganics										
Aluminum	41,400		9,440		18,988	22	22	100%	23,600	Yes
Antimony	15.5	J	0.49	J	3.3	22	20	91%	6.34	Yes
Arsenic	12.4		3.9		7.4	22	22	100%	9.14	Yes
Barium	235		117		169	22	22	100%	175	Yes
Beryllium	1.3		0.45	J	0.74	12	12	100%	1.17	Yes
Cadmium	0.41[i]	nd	0.04[i]	nd	0.13	12	5	41.7%	0.416	No
Calcium	36,500		11,600		19,875	12	12	100%	na	No[j]
Chromium	24.7	J	5.8[i]	nd	14.5	12	10	83.3%	27.7	No
Cobalt	16.9		7.8		11.2	22	22	100%	12.9	Yes
Copper	2,750		16.3		194	22	22	100%	28.7	Yes
Iron	27,700		16,300		19,700	12	12	100%	na	No[j]
Lead	6,430		7.4		773	22	22	100%	7.33	Yes
Magnesium	15,000		5,930		9,541	12	12	100%	na	No[j]
Manganese	751		482	J	598	12	12	100%	361	Yes
Molybdenum	5.6	J	0.21	J	1.4	12	12	100%	4.58	Yes
Nickel	18.8	J	7.65[i]	nd	11.7	12	3	25%	29.1	No
Phosphorus (total)	780		390		590	12	12	100%	na	No
Potassium	7,420		2,520		4,617	12	12	100%	na	No[j]
Selenium	0.98	J	0.095	J	0.45	12	3	25%	na	Yes
Sodium	8,550		900		4,325	12	12	100%	na	No[j]
Vanadium	34		17.5		24.7	12	12	100%	97	No
Zinc	345		37.7		84.6	22	22	100%	51	Yes

Notes:

[a] Surface soil depth equal to 0 - 1 ft bgs.
[b] Maximum detected concentration of original or duplicate soil samples (0 - 1 ft bgs).
[c] Minimum concentration of original or duplicate samples (0 - 1 ft bgs).
[d] The arithmetic mean soil concentration for soil samples collected in the interval 0 - 1 ft bgs.
[e] Total number of soil samples collected in the interval 0 - 1 ft bgs (excludes duplicate samples).
[f] Total number of detections in soil samples collected in the interval 0 - 1 ft bgs (excludes duplicate samples).
[g] Background upper tolerance limit for Fort Irwin Soils. Source: Parsons Engineering Science, Inc., 1996.
[h] Constituent is considered a chemical of potential concern (COPC) if maximum concentration exceeds BUTL.
[i] Minimum concentration is a non-detect value and is assumed to be one-half the detection limit.
[j] Analyte eliminated as a COPC based on its role as an essential dietary nutrient (refer to Section 6.2.4).

J - estimated value
mg/kg - milligrams per kilogram
na - not applicable
nd - not detected

TABLE 6-5

SUMMARY OF CHEMICALS OF POTENTIAL CONCERN[a]
SITE FTIR-38 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

Surface Soils [b]
Inorganics
Aluminum
Antimony
Arsenic
Barium
Beryllium
Cobalt
Copper
Lead
Manganese
Molybdenum
Selenium
Zinc

Notes:
[a] Refer to Table 6-4 for COPC selection.
[b] Surface soil depth equal to 0 - 1 ft bgs.

COPC - Chemical of potential concern

TABLE 6-6

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR SURFACE SOILS[a]
SITE FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER

(Page 1 of 2)

Constituent	Soil Concentration (mg/kg) Maximum [b]		Minimum [c]		Mean [d]	Number of Samples [e]	Detections [f]	Detection Frequency	BUTL [g] (mg/kg)	COPC [h]
Inorganics										
Aluminum	34,700		8,770		15,159	13	13	100%	23,600	Yes
Antimony	94.2		0.97	J	12.7	13	5	38.5%	6.34	Yes
Arsenic	26.4		2.8		7.2	13	13	100%	9.14	Yes
Barium	1,230		131		285	13	13	100%	175	Yes
Beryllium	0.72	J	0.04[i]	nd	0.32	3	2	66.7%	1.17	No
Cadmium	53.9		0.19	J	6.5	13	10	76.9%	0.416	Yes
Calcium	20,900		18,800		20,133	3	3	100%	na	No[j]
Chromium	94.4		7.7		21.1	13	13	100%	27.7	Yes
Cobalt	18.7		5.4		8.8	13	13	100%	12.9	Yes
Copper	12,900		13.2		1,154	13	13	100%	28.7	Yes
Iron	86,900		18,800		63,100	3	3	100%	na	No[j]
Lead	38,400		7.8		3,816	13	13	100%	7.33	Yes
Magnesium	5,510		2,860		4,160	3	3	100%	na	No[j]
Manganese	1,380		290		549	13	13	100%	361	Yes
Mercury	7.6		0.05[i]	nd	0.73	13	8	61.5%	0.202	Yes
Molybdenum	11.4	J	1	J	7.1	3	2	66.7%	4.58	Yes
Nickel	78.6		7.8		20.4	13	13	100%	29.1	Yes
Potassium	3,400		1,890		2,757	3	3	100%	7382	No[j]
Selenium	1.05[i]	nd	0.37[i]	nd	0.72	13	5	38.5%	na	Yes
Silver	74		0.73	J	11.6	13	11	84.6%	na	Yes
Sodium	2,460		479		1,570	3	3	100%	na	No[j]
Vanadium	31.7		18.6[i]	nd	24.7	3	3	100%	97	No
Zinc	8,740		43.7		1,321	13	13	100%	51	Yes

TABLE 6-6

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR SURFACE SOILS[a]
SITE FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER

(Page 2 of 2)

Constituent	Soil Concentration (mg/kg) Maximum [b]	Minimum [c]	Mean [d]	Number of Samples [e]	Detections [f]	Detection Frequency	BUTL [g] (mg/kg)	COPC [h]
Organics Coumpounds								
2,4,6-Trinitrotoluene	0.90	0.26	0.47	3	1	33.3%	na	Yes
TPH								
TRPH	88	15.5	40.2	3	1	33.3%	na	Yes

Notes:

[a] Surface soil depth equal to 0 - 1 ft bgs.
[b] Maximum detected concentration of original or duplicate soil samples (0 - 1 ft bgs).
[c] Minimum concentration of original or duplicate samples (0 - 1 ft bgs).
[d] The arithmetic mean soil concentration for soil samples collected in the interval 0 - 1 ft bgs.
[e] Total number of soil samples collected in the interval 0 - 1 ft bgs (excludes duplicate samples).
[f] Total number of detections in soil samples collected in the interval 0 - 1 ft bgs (excludes duplicate samples).
[g] Background upper tolerance limit for Fort Irwin Soils. Source: Parsons Engineering Science, Inc., 1996.
[h] Constituent is considered a chemical of potential concern (COPC) if maximum concentration exceeds BUTL.
[i] Minimum concentration is a non-detect value and is assumed to be one-half the detection limit.
[j] Analyte eliminated as a COPC based on its role as an essential dietary nutrient (refer to Section 6.2.4).

J - estimated value
mg/kg - milligrams per kilogram
na - not applicable
nd - not detected
TPH - Total petroleum hydrocarbons
TRPH - Total recoverable petroleum hydrocarbons

TABLE 6-7

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR SUBSURFACE SOILS[a]
SITE FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 1 of 2)

	Soil Concentration (mg/kg)					Number of		Detection	BUTL [g]	
Constituent	Maximum [b]		Minimum [c]		Mean [d]	Samples [e]	Detections [f]	Frequency	(mg/kg)	COPC [h]
Inorganics										
Aluminum	9,310		8,000		8,655	2	2	100%	23,600	No
Antimony	4.4	J	2	J	3	2	2	100%	6.34	No
Arsenic	9.6		7.8		8.7	2	2	100%	9.14	Yes
Barium	251		193		222	2	2	100%	175	Yes
Beryllium	0.57	J	0.39	J	0.48	2	2	100%	1.17	No
Cadmium	5.9		2.9	J	4.4	2	2	100%	0.416	Yes
Calcium	25,700		16,900		21,300	2	2	100%	na	No[j]
Chromium	15.1		10.1	J	12.6	2	2	100%	27.7	No
Cobalt	8.9	J	7.1	J	8.0	2	2	100%	12.9	No
Copper	222		168		195	2	2	100%	28.7	Yes
Iron	32,000		16,800		24,400	2	2	100%	na	No[j]
Lead	154		80.8		117	2	2	100%	7.33	Yes
Magnesium	4,380		4,080		4,230	2	2	100%	na	No[j]
Manganese	532		427		480	2	2	100%	361	Yes
Mercury	0.21		0.2		0.2	2	2	100%	0.202	Yes
Molybdenum	2.6	J	1.3	J	2.0	2	2	100%	4.58	No
Nickel	17.8	J	11.6	J	14.7	2	2	100%	29.1	No
Potassium	2,780		2,170		2,475	2	2	100%	na	No[j]
Selenium	0.75	J	0.385[i]	nd	0.568	2	1	50%	na	Yes
Silver	9.9	J	5.1	J	7.5	2	2	100%	na	Yes
Sodium	886		644		765	2	2	100%	na	No[j]
Vanadium	20.1		16.8		18.5	2	2	100%	97	No
Zinc	761		380		571	2	2	100%	51	Yes
TPH										
TRPH	180		78		130	2	2	100%	na	Yes

TABLE 6-7

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR SUBSURFACE SOILS[a]
SITE FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER, FORT IRWIN

Notes:
[a] Soil depth equal to >1 - 10 ft bgs.
[b] Maximum detected concentration of original or duplicate soil samples (>1 - 10 ft bgs).
[c] Minimum concentration of original or duplicate samples (>1 - 10 ft bgs).
[d] The arithmetic mean soil concentration for soil samples collected in the interval >1 - 10 ft bgs.
[e] Total number of soil samples collected in the interval >1 - 10 ft bgs (excludes duplicate samples).
[f] Total number of detections in soil samples collected in the interval >1 - 10 ft bgs (excludes duplicate samples).
[g] Background upper tolerance limit for Fort Irwin Soils. Source: Parsons Engineering Science, Inc., 1996.
[h] Constituent is considered a chemical of potential concern (COPC) if maximum concentration exceeds BUTL.
[i] Minimum concentration is a non-detect value and is assumed to be one-half the detection limit.
[j] Analyte eliminated as a COPC based on its role as an essential dietary nutrient (refer to Section 6.2.4).

J - estimated value
mg/kg - milligrams per kilogram
na - not applicable
nd - not detected
TPH - Total petroleum hydrocarbons
TRPH - Total recoverable petroleum hydrocarbons

TABLE 6-8

SUMMARY OF CHEMICALS OF POTENTIAL CONCERN[a]
SITE FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER, FORT IRWIN

Surface Soils [b]	Subsurface Soils [c]
Inorganics	**Inorganics**
Aluminum	Arsenic
Antimony	Barium
Arsenic	Cadmium
Barium	Copper
Cadmium	Lead
Chromium	Manganese
Cobalt	Mercury
Copper	Selenium
Lead	Silver
Manganese	Zinc
Mercury	
Molybdenum	**TPH**
Nickel	TRPH
Selenium	
Silver	
Zinc	
Explosives	
2,4,6-Trinitrotoluene	
TPH	
TRPH	

Notes:

[a] Refer to Tables 6-6 and 6-7 for COPC selection

[b] Surface soil depth equal to 0 - 1 ft bgs

[c] Subsurface soil depth equal to >1 - 10 ft bgs

COPC - Chemical of potential concern

TPH - Total petroleum hydrocarbons

TRPH - Total residual petroleum hydrocarbons

TABLE 6-9

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR SURFACE SOILS[a]
SITE FTIR-40 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

Constituent	Soil Concentration (mg/kg) Maximum[b]	Minimum[c]		Mean[d]	Number of Samples[e]	Detections[f]	Detection Frequency	BUTL[g] (mg/kg)	COPC[h]
Inorganics									
Arsenic	10.9	8.2		9.31	10	10	100%	9.14	Yes
Cadmium	0.5	0.15	J	0.283	10	10	100%	0.416	Yes
Lead	259	9.5		38.45	10	10	100%	7.33	Yes
Zinc	213	46.7	J	73.93	10	10	100%	51	Yes

Notes:
[a] Surface soil depth equal to 0 - 1 ft bgs.
[b] Maximum detected concentration of original or duplicate soil samples (0 - 1 ft bgs).
[c] Minimum concentration of original or duplicate samples (0 - 1 ft bgs).
[d] The arithmetic mean soil concentration for soil samples collected in the interval 0 - 1 ft bgs.
[e] Total number of soil samples collected in the interval 0 - 1 ft bgs (excludes duplicate samples).
[f] Total number of detections in soil samples collected in the interval 0 - 1 ft bgs (excludes duplicate samples).
[g] Background upper tolerance limit for Fort Irwin Soils. Source: Parsons Engineering Science, Inc., 1996.
[h] Constituent is considered a chemical of potential concern (COPC) if maximum concentration exceeds BUTL.

J - estimated value
mg/kg - milligrams per kilogram

TABLE 6-10

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR
SUBSURFACE SOILS[a]
SITE FTIR-40 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 1 of 2)

Constituent	Soil Concentration					Number of		Detection	BUTL[g]	
	Maximum[b]		Minimum[c]		Mean[d]	Samples[e]	Detections[f]	Frequency	(mg/kg)	COPC[h]
Inorganics (mg/kg)										
Aluminum	12,600		8,260		10,743	16	16	100%	23,600	No
Antimony	2.15[i]	nd	0.15	J	1.5	16	6	37.5%	6.34	No
Arsenic	17.7		7.9		9.9	16	16	100%	9.14	Yes
Barium	195		96.2		162	16	16	100%	175	Yes
Beryllium	0.84		0.14	J	0.40	16	14	87.5%	1.17	No
Cadmium	6.1		0.18	J	0.6	16	9	56.3%	0.416	Yes
Calcium	51,600		12,400		25,363	16	16	100%	na	No[j]
Chromium	18.6		9.2		14.0	16	16	100%	27.7	No
Cobalt	9.3		5.8		7.1	16	16	100%	12.9	No
Copper	78.8		10		19	16	16	100%	28.7	Yes
Iron	22,100		10,500		18,063	16	16	100%	na	No[j]
Lead	133		4.7		16	16	16	100%	7.33	Yes
Magnesium	4,940		3,620		4,381	16	16	100%	na	No[j]
Manganese	502		203		297	16	16	100%	361	Yes
Mercury	0.74		0.05[i]	nd	0.12	16	5	31.3%	0.202	Yes
Molybdenum	10.6	J	0.425	J	1.3	16	15	93.8%	4.58	Yes
Nickel	17.3	J	8.4	J	12.4	16	16	100%	29.1	No
Potassium	2,910		1,750		2,145	16	16	100%	na	No[j]
Selenium	1.1[i]	nd	0.19	J	0.86	16	5	31.3%	na	Yes
Silver	4.9	J	0.48	J	1.3	16	2	12.5%	na	Yes
Sodium	1,530		85[i]	nd	493	16	15	93.8%	na	No[j]
Thallium	0.65	J	0.20[i]	nd	0.58	16	1	6.3%	1.91	No
Vanadium	35.6		19		26.8	16	16	100%	97	No
Zinc	2,310		30.6		198	16	16	100%	51	Yes
Organic Compounds (µg/kg)										
Benzo(a)anthracene	365[i]	nd	90[i]	nd	107	16	1	6.3%	na	Yes
Benzo(a)pyrene	365[i]	nd	89	J	107	16	1	6.3%	na	Yes

TABLE 6-10

SELECTION OF CHEMICALS OF POTENTIAL CONCERN FOR
SUBSURFACE SOILS[a]
SITE FTIR-40 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 2 of 2)

Constituent	Soil Concentration					Number of		Detection	BUTL[g]	
	Maximum[b]		Minimum[c]		Mean[d]	Samples[e]	Detections[f]	Frequency	(mg/kg)	COPC[h]
Benzo(b)fluoranthene	200	J	90[i]	nd	101	16	2	12.5%	na	Yes
Benzo(g,h,i)perylene	365[i]	nd	30	J	103	16	1	6.3%	na	Yes
Benzo(k)fluoranthene	120	J	67	J	90.4	16	2	12.5%	na	Yes
Benzoic acid	365[i]	nd	67	J	106	16	1	6.3%	na	Yes
bis (2-Ethylhexyl) phthalate	410		77	J	155	16	13	81.3%	na	Yes
Chrysene	270[i]	nd	150	J	250	16	2	12.5%	na	Yes
di-n-Octylphthalate	365		57	J	128	16	9	56.3%	na	Yes
Fluoranthene	130	J	39	J	89.3	16	2	12.5%	na	Yes
Indeno(1,2,3-cd)pyrene	365[i]	nd	32	J	104	16	1	6.3%	na	Yes
Phenanthrene	365[i]	nd	90[i]	nd	107	16	1	6.3%	na	Yes
Pyrene	150	J	86	J	93.5	16	2	12.5%	na	Yes
TPH (mg/kg)										
TRPH	270		16[i]	nd	143	2	1	50	na	Yes

Notes:

[a] Soil depth equal to 1 - 10 ft bgs.
[b] Maximum detected concentration of original or duplicate soil samples (>1 - 10 ft bgs).
[c] Minimum concentration of original or duplicate samples (>1 - 10 ft bgs).
[d] The arithmetic mean soil concentration for soil samples collected in the interval >1 - 10 ft bgs.
[e] Total number of soil samples collected in the interval >1 - 10 ft bgs (excludes duplicate samples).
[f] Total number of detections in soil samples collected in the interval >1 - 10 ft bgs (excludes duplicate samples).
[g] Background upper tolerance limit for Fort Irwin Soils. Source: Parsons Engineering Science, Inc., 1996.
[h] Constituent is considered a chemical of potential concern (COPC) if maximum concentration exceeds BUTL.
[i] Minimum concentration is a non-detect value and is assumed to be one-half the detection limit.
[j] Analyte eliminated as a COPC based on its role as an essential dietary nutrient (refer to Section 6.2.4).

J - estimated value
mg/kg - milligrams per kilogram
na - not applicable
nd - not detected
SVOC - Semivolatile organic compounds
TPH - Total petroleum hydrocarbons
TRPH - Total recoverable petroleum hydrocarbons

TABLE 6-11

SUMMARY OF CHEMICALS OF POTENTIAL CONCERN[a]
SITE FTIR-40 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

Surface Soils [b]	Subsurface Soils [c]
Inorganics	**Inorganics**
Arsenic	Arsenic
Cadmium	Barium
Lead	Cadmium
Zinc	Copper
	Lead
	Manganese
	Mercury
	Selenium
	Silver
	Zinc
	SVOC
	Benz(a)anthracene
	Benzo(a)pyrene
	Benzo(b)fluoranthene
	Benzo(g,h,i) perylene
	Benzo(k)fluoranthene
	Benzoic acid
	bis (2-Ethylhexyl) phthalate
	Chrysene
	di-n-Octylphthalate
	Fluoranthene
	Indeno(1,2,3-cd)pyrene
	Phenanthrene
	Pyrene
	TPH
	TRPH

Notes:
[a] Refer to Tables 6-9 and 6-10 for COPC selection
[a] Surface soil depth equal to 0 - 1 ft bgs
[a] Subsurface soil depth equal to >1 - 10 ft bgs

SVOC - Semivolatile organic compounds
TPH - Total petroleum hydrocarbons
TRPH - Total residual petroleum hydrocarbons

TABLE 6-12

EXPOSURE POINT CONCENTRATION DETERMINATION FOR SURFACE SOILS[a]
SITE FTIR-38 AREA 1
NATIONAL TRAINING CENTER, FORT IRWIN

Constituent	Maximum Concentration (mg/kg)		Minimum Concentration [a] (mg/kg)		95% UCL Concentration [b] (mg/kg)	Exposure Point Concentration [c] (mg/kg)
Inorganics						
Aluminum	30,900		25,100		NC	30,900
Arsenic	15.5		13		NC	15.5
Barium	244		219		NC	244
Beryllium	1.7	J	1.4	J	NC	1.7
Cadmium	1.1	J	0.26	J	NC	1.1
Chromium	29.9	J	24.5	J	NC	29.9
Cobalt	15.9	J	13.8	J	NC	15.9
Copper	79.8		41.3		NC	79.8
Lead	190		36.5		NC	190
Manganese	765		715		NC	765
Molybdenum	5.5		0.980		NC	5.5
Zinc	177		97.2		NC	177

Notes:

NC - Not calculated.

[a] For samples which were non-detect (nd) one-half the detection limit was assumed.

[b] The 95 percent upper confidence limit (95 % UCL) was calculated based on a log-normal distribution.

[c] The exposure point concentration (EPC) is equal to the lower of the maximum or 95 % UCL concentration. When the 95 % UCL concentration could not be calculated, the maximum concentration was assumed as the EPC.

J - Estimated value.

mg/kg - Milligram per kilogram.

nd - not detected

TABLE 6-13

EXPOSURE POINT CONCENTRATION DETERMINATION FOR SUBSURFACE SOILS
SITE FTIR-38 AREA 1
NATIONAL TRAINING CENTER, FORT IRWIN

Constituent	Maximum Concentration (mg/kg)	Minimum Concentration [a] (mg/kg)	95% UCL Concentration [b] (mg/kg)	Exposure Point Concentration [c] (mg/kg)
Inorganics				
Aluminum	30,000	14,400	NC	30,000
Barium	198	64.5	NC	198
Beryllium	1.6	0.57	NC	1.6
Chromium	33.5	14.5	NC	33.5
Cobalt	14.1	7.4	NC	14.1
Copper	49.9	22.8	NC	49.9
Lead	105	23.2	NC	105
Manganese	801	362	NC	801
Vanadium	421	35.6	NC	421
Zinc	215	149	NC	215

Notes:

NC - Not calculated.

[a] For samples which were non-detect (nd) one-half the detection limit was assumed.

[b] The 95 percent upper confidence limit (95 % UCL) was calculated based on a log-normal distribution.

[c] The exposure point concentration (EPC) is equal to the lower of the maximum or 95 % UCL concentration. When the 95 % UCL concentration could not be calculated, the maximum concentration was assumed as the EPC.

TABLE 6-14

EXPOSURE POINT CONCENTRATION DETERMINATION FOR SURFACE SOILS
SITE FTIR-38 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

Constituent	Maximum Concentration (mg/kg)		Minimum Concentration [a] (mg/kg)		95 % UCL Concentration [b] (mg/kg)	Exposure Point Concentration [c] (mg/kg)
Inorganics						
Aluminum	41,400		9,440		22,051	22,051
Antimony	15.5	J	0.49	J	5.5	5.5
Arsenic	12.4		3.9		8.6	8.6
Barium	235		117		184	184
Beryllium	1.3		0.45	J	0.92	0.92
Cobalt	16.9		7.8		12.2	12.2
Copper	2,750		16.3		230	230
Lead	6,430		7.4		3,753	3,753
Manganese	751		482	J	654	654
Molybdenum	5.6	J	0.21	J	3.5	3.5
Selenium	1.0	J	0.095	J	0.80	0.80
Zinc	345		37.7		102	102

Notes:
NC - Not calculated.
[a] For samples which were non-detect (nd) one-half the detection limit was assumed.
[b] The 95 percent upper confidence limit (95 % UCL) was calculated based on a log-normal distribution.
[c] The exposure point concentration (EPC) is equal to the lower of the maximum or 95 % UCL concentration. When the 95 % UCL concentration could not be calculated, the maximum concentration was assumed as the EPC.

J - Estimated value.
mg/kg - Milligram per kilogram.

TABLE 6-15

EXPOSURE POINT CONCENTRATION DETERMINATION FOR SURFACE SOILS
SITE FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER, FORT IRWIN

Constituent	Maximum Concentration (mg/kg)		Minimum Concentration [a] (mg/kg)		95 % UCL Concentration [b] (mg/kg)	Exposure Point Concentration [c] (mg/kg)
Inorganics						
Aluminum	34,700		8770		19,202	19,202
Antimony	94.2		0.97	J	36.1	36.1
Arsenic	26.4		2.8		10.3	10.3
Barium	1,230		131		405	405
Cadmium	53.9		0.19	J	77.3	53.9
Chromium	94.4		7.7		31.9	31.9
Cobalt	18.7		5.4		10.6	10.6
Copper	12,900		13.2		12,069	12,069
Lead	38,400		7.8		566,344	38,400
Manganese	1,380		290		714	714
Mercury	7.6		0.05	nd	1.9	1.9
Molybdenum	11.4		1.0	J	223,024,916	11.4
Nickel	78.6		7.8		32.6	32.6
Selenium	1.1	(nd)	0.37	nd	0.94	0.94
Silver	74.0		0.73	J	74.8	74.0
Zinc	8,740		43.7		14,768	8,740
Organic Compounds						
2,4,6-Trinitrotoluene	0.90		0.26		54	1
TPH						
TRPH	88.0		15.5		378,195	88.0

Notes:
NC - Not calculated.
[a] For samples which were non-detect (nd) one-half the detection limit was assumed.
[b] The 95 percent upper confidence limit (95 % UCL) was calculated based on a log-normal distribution.
[c] The exposure point concentration (EPC) is equal to the lower of the maximum or 95 % UCL concentration. When the 95 % UCL concentration could not be calculated, the maximum concentration was assumed as the EPC.

J - Estimated value.
mg/kg - Milligram per kilogram.
nd - Not detected.
TPH - Total petroleum hydrocarbons

TABLE 6-16

EXPOSURE POINT CONCENTRATION DETERMINATION FOR SUBSURFACE SOILS
SITE FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER, FORT IRWIN

Constituent	Maximum Concentration (mg/kg)		Minimum Concentration [a] (mg/kg)		95% UCL Concentration [b] (mg/kg)	Exposure Point Concentration [c] (mg/kg)
Inorganics						
Arsenic	9.6		7.8		NC	9.6
Barium	251		193		NC	251
Cadmium	5.9		2.9	J	NC	5.9
Copper	222		168		NC	222
Lead	154		80.8		NC	154
Manganese	532		427		NC	532
Mercury	0.21		0.2		NC	0.21
Selenium	0.75	J	0.385'	nd	NC	0.75
Silver	9.9	J	5.1	J	NC	9.9
Zinc	761		380		NC	761
TPH						
TRPH	180		78		NC	180

Notes:

NC - Not calculated.

[a] For samples which were non-detect (nd) one-half the detection limit was assumed.

[b] The 95 percent upper confidence limit (95 % UCL) was calculated based on a log-normal distribution.

[c] The exposure point concentration (EPC) is equal to the lower of the maximum or 95 % UCL concentration. When the 95 % UCL concentration could not be calculated, the maximum concentration was assumed as the EPC.

J - Estimated value.

mg/kg - Milligram per kilogram.

nd - not detected

na - not applicable

TABLE 6-17

EXPOSURE POINT CONCENTRATIO DETERMINATION FOR SURFACE SOILS
SITE FTIR-40 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

Constituent	Maximum Concentration (mg/kg)	Minimum Concentration [a] (mg/kg)		95 % UCL Concentration [b] (mg/kg)	Exposure Point Concentration [c] (mg/kg)
Inorganics					
Arsenic	10.9	8.2		9.8	9.8
Cadmium	0.50	0.15	J	0.35	0.35
Lead	259	9.5		82.4	82.4
Zinc	213	46.7	J	101	101

Notes:
NC - Not calculated.
[a] For samples which were non-detect (nd) one-half the detection limit was assumed.
[b] The 95 percent upper confidence limit (95 % UCL) was calculated based on a log-normal distribution.
[c] The exposure point concentration (EPC) is equal to the lower of the maximum or 95 % UCL concentration. When the 95 % UCL concentration could not be calculated, the maximum concentration was assumed as the EPC.

J - Estimated value.
mg/kg - Milligram per kilogram.

TABLE 6-18

EXPOSURE POINT CONCENTRATION DETERMINATION FOR SUBSUFACE SOILS
SITE FTIR-40 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

Constituent	Maximum Concentration (mg/kg)	Minimum Concentration [a] (mg/kg)		95 % UCL Concentration [b] (mg/kg)	Exposure Point Concentration [c] (mg/kg)
Inorganics					
Arsenic	17.7	7.9		10.8	10.8
Barium	195	96.2		178	178
Cadmium	6.1	0.18	J	0.80	0.80
Copper	78.8	10.0		23.5	23.5
Lead	133	4.7		21	21
Manganese	502	203		327	327
Mercury	0.74	0.05	nd	0.17	0.17
Molybdenum	10.6	0.425	J	1.7	1.7
Selenium	1.1	0.19	J	1.2	1.1
Silver	4.9	0.48	J	1.5	1.5
Zinc	2,310	30.6		237	237
Organic Compounds					
Benzo(a)anthracene	0.365	0.090	nd	0.125	0.125
Benzo(a)pyrene	0.365	0.089	J	0.125	0.125
Benzo(b)fluoranthene	0.200	0.090	nd	0.112	0.112
Benzo(g,h,i)perylene	0.365	0.030	J	0.130	0.130
Benzo(k)fluoranthene	0.120	0.067	J	0.095	0.095
Benzoic acid	0.365	0.067	J	0.124	0.124
bis (2-Ethylhexyl) phthalate	0.410	0.077	J	0.205	0.205
Chrysene	0.270	0.150	J	0.272	0.270
di-n-Octylphthalate	0.365	0.057	J	0.199	0.199
Fluoranthene	0.130	0.039	J	0.100	0.100
Indeno(1,2,3-cd)pyrene	0.365	0.032	J	0.129	0.129
Phenanthrene	0.365	0.090	nd	0.125	0.125
Pyrene	0.150	0.086	J	0.099	0.099

Notes:

NC - Not calculated.

[a] For samples which were non-detect (nd) one-half the detection limit was assumed.

[b] The 95 percent upper confidence limit (95 % UCL) was calculated based on a log-normal distribution.

[c] The exposure point concentration (EPC) is equal to the lower of the maximum or 95 % UCL concentration. When the 95 % UCL concentration could not be calculated, the maximum concentration was assumed as the EPC.

J - Estimated value.

mg/kg - Milligram per kilogram.

nd - Not detected.

TABLE 6-19

EXPOSURE PARAMETERS AND ASSUMPTIONS FOR HYPOTHETICAL FUTURE RESIDENTS
SITES FTIR-38 AND FTIR-40
NATIONAL TRAINING CENTER, FORT IRWIN

		Exposure Assumptions		
Exposure Parameter	Units	Adult	Child	Source
Soil Concentration - C_s	mg/kg	Chemical-specific	Chemical-specific	Not applicable
Body Weight - BW	kg	70	15	USEPA, 1989
Soil Ingestion Rate - IR	mg/day	100	200	USEPA, 1997
Inhalation Rate - InhR	m^3/day	20	10	USEPA, 1997
Exposure Frequency - EF	day/yr	350	350	USEPA, 1997
Exposure Duration - ED	yr	24	6	USEPA, 1997
Dermal Surface Area - SA	cm^2/event	5,700	2,800	USEPA, 1999
Skin Adherence Factor - AF	mg/cm^2	0 07	0 2	USEPA, 1999
Particulate Emission Factor - PEF	m^3/kg	1 32E+09	1 32E+09	USEPA, 2000
Averaging Time - AT	days			
Carcinogens		25,550	25,550	USEPA, 1989
Noncarcinogens		8,760	2,190	USEPA, 1989
Chemical-Specific Skin Absorption Factor - ABS	unitless			CalEPA, 1994a
Arsenic		0.03	0.03	
Cadmium		0.001	0.001	
Other inorganics		0.01	0 01	
Polynuclear aromatic hydrocarbons (PAHs)		0 15	0 15	
Other semi-volatile organics		0 10	0 10	

Sources:

Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (USEPA, 1989)

Preliminary Endangerment Assessment Guidance Manual (CalEPA 1994a)

Exposure Factors Handbook (USEPA 1997)

RAGS Part E: Supplemental Guidance for Dermal Risk Assessment (USEPA 1999)

Region IX Preliminary Remediation Goals (PRGs) 1999 (USEPA, 2000)

Notes:

cm^2/event - Square centimeters per event
day/yr - Days per year
hr/day - Hours per day
kg - Kilograms
m^3/day - Cubic meters per day
m^3/kg - Cubic meters per kilogram
mg/cm^2 - Milligrams per square centimeter
mg/day - Milligrams per day
mg/kg - Milligrams per kilogram

TABLE 6-20

EXPOSURE PARAMETERS AND ASSUMPTIONS FOR INDUSTRIAL WORKERS
SITES FTIR-38 AND FTIR-40
NATIONAL TRAINING CENTER, FORT IRWIN

Exposure Parameter	Units	Exposure Assumptions	Source
Soil Concentration - C_s	mg/kg	Chemical-specific	Not applicable
Body Weight - BW	kg	70	USEPA, 1989
Soil Ingestion Rate - IR	mg/day	50	USEPA, 1997
Inhalation Rate - InhR	m^3/day	20	USEPA, 1997
Exposure Frequency - EF	day/yr	250	USEPA, 1997
Exposure Duration - ED	yr	25	USEPA, 1997
Dermal Surface Area - SA	cm^2/event	3,300	USEPA, 1999
Skin Adherence Factor - AF	mg/cm^2	0.2	USEPA, 1999
Particulate Emission Factor - PEF	m^3/kg		
Normal conditions		1.32E+09	USEPA, 2000
Windy conditions		1.60E+07	Parsons, 1995
Averaging Time - AT	days		
Carcinogens		25,550	USEPA, 1989
Noncarcinogens		9,125	USEPA, 1989
Chemical-Specific Skin Absorption Factor - ABS	unitless		CalEPA, 1994a
Arsenic		0.03	
Cadmium		0.001	
Other inorganics		0.01	
Polynuclear aromatic hydrocarbons (PAHs)		0.15	
Other semi-volatile organics		0.10	

Sources:

Risk Assessment Guidance for Superfund (RAGS): Volume I: Human Health Evaluation Manual (USEPA, 1989)

Preliminary Endangerment Assessment Guidance Manual (CalEPA, 1994a)

Exposure Factors Handbook (USEPA 1997)

RAGS Part E: Supplemental Guidance for Dermal Risk Assessment (USEPA 1999)

Region IX Preliminary Remediation Goals (PRGs) 1999 (USEPA, 2000)

Based on the highest annual average respirable particulate concentration measured by the MDAQMD (Parsons, 1995).

Notes:

cm^2/event - Square centimeters per event

day/yr - Days per year

hr/day - Hours per day

kg - Kilograms

m^3/day - Cubic meters per day

m^3/kg - Cubic meters per kilogram

mg/cm^2 - Milligrams per square centimeter

mg/day - Milligrams per day

mg/kg - Milligrams per kilogram

TABLE 6-21

TOXICITY VALUES IN THE BASELINE HUMAN HEALTH RISK ASSESSMENT
SITES FTIR-38 AND FTIR-40
NATIONAL TRAINING CENTER, FORT IRWIN

	Cancer Slope Factor - CSF $(mg/kg\text{-}d)^{-1}$				Reference Dose - RfD (mg/kg-d)			
Constituent	**Oral**		**Inhalation**		**Oral**		**Inhalation**	
Inorganics								
Aluminum	na		na		1.0E+00	N	1.4E-03	N
Antimony	na		na		4.0E-04	I	4.0E+00	R
Arsenic	1.5E+00	I	1.5E+01	I	3.0E-04	I	3.0E-04	R
Barium	na		na		7.0E-02	I	1.4E-04	H
Beryllium	na		8.4E+00	I	2.0E-03	I	5.7E-06	I
Cadmium	na		6.3E+00	I	5.0E-04	I	5.0E-04	R
Chromium, total[a]	na		4.2E+01	I	1.5E+00	I	1.5E+00	R
Cobalt	na		na		6.0E-02	N	6.0E-02	R
Copper	na		na		3.7E-02	H	3.7E-02	R
Lead	na		na		na		na	
Manganese	na		na		2.4E-02	I	1.4E-05	I
Mercury	na		na		3.0E-04	I	3.0E-04	R
Molybdenum	na		na		5.0E-03	H	5.0E-03	R
Nickel	na		na		2.0E-02	I	2.0E-02	R
Selenium	na		na		5.0E-03	I	5.0E-03	R
Silver	na		na		5.0E-03	I	5.0E-03	R
Vanadium	na		na		7.0E-03	H	7.0E-03	R
Zinc	na		na		3.0E-01	I	3.0E-01	R
SVOC								
Benzo(a)anthracene	7.3E-01	N	3.1E-01	N	na		na	
Benzo(a)pyrene	7.3E+00	I	3.1E+00	N	na		na	
Benzo(b)fluoranthene	7.3E-01	N	3.1E-01	N	na		na	
Benzo(g,h,i)perylene	na		na		na		na	
Benzo(k)fluoranthene	7.3E-02	N	3.1E-02	N	na		na	
Benzoic acid	na		na		4.0E+00	I	4.0E+00	R
bis (2-Ethylhexyl) phthalate	1.4E-02	I	1.4E-02	R	2.0E-02	I	2.2E-02	R
Chrysene	7.3E-03	N	3.1E-03	N	na		na	
di-n-Octylphthalate	na		na		2.0E-02	I	2.0E-02	R
Fluoranthene	na		na		4.0E-02	I	4.0E-02	R
Indeno(1,2,3-cd)pyrene	7.3E-01	N	3.1E-01	N	na		na	
Phenanthrene	na		na		na		na	
Pyrene	na		na		3.0E-02	I	3.0E-02	R
2,4,6-Trinitrotoluene	3.0E-02	I	3.0E-02	R	5.0E-04	I	5.0E-04	R
TPH								
TRPH	na		na		na		na	

Notes:
[a] Chromium, total evaluated assuming a 1:6 ratio of CrVI:CrIII (USEPA 2000)

CSF - Cancer slope factor
mg/kg-d - Milligram per kilogram per day
na - Not available.
RfD - Reference dose
SVOC - Semi-volatile organic compounds
TPH - Total petroleum hydrocarbons.
TRPH - Total recoverable petroleum hydrocarbons.

I IRIS Database (USEPA, 2001)
H HEAST (USEPA 1995)
N National Center for Environmental Assessment
R Route extrapolation
X Withdrawn

TABLE 6-22

CANCER RISK AND NONCANCER HAZARD RESULTS[a]
SITE FTIR-38 - AREAS 1 AND 2
NATIONAL TRAINING CENTER, FORT IRWIN

	Site FTIR-38			
	Area 1		Area 2	
Risk Endpoint/Exposure Scenario	**Surface Soil**	**Subsurface Soil**	**Surface Soil**	**Subsurface Soil**
Total Cancer Risk				
Hypothetical Future Resident	4.0E-05	1.6E-07	2.2E-05	NA[b]
Future Industrial Worker	7.1E-06	1.3E-06	3.3E-06	NA[b]
USEPA Acceptable Risk Range[c]:	1.0E-04 - 1.0E-06	1.0E-04 - 1.0E-06	1.0E-04 - 1.0E-06	1.0E-04 - 1.0E-06
Primary COPCs:	Arsenic, Chromium	Chromium	Arsenic	NA
Total Hazard Index (HI)				
Hypothetical Future Resident	0.50	0.51	0.41	NA[b]
Future Industrial Worker	0.28	0.28	0.37	NA[b]
USEPA Acceptable Risk Range[c]:	1.0	1.0	1.0	1.0
Primary COPCs:	NA	NA	NA	NA

Notes:

[a] Refer to 'Appendix H' for receptor-specific and chemical-specific cancer risk and noncancer hazard calculations.

[b] Subsurface soils were not evaluated fror Site FTIR-38 Area 2, consistent with the surficial nature of the contaminant source at this site (refer to Section 4.2).

[c] Source: Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions (USEPA, 1991a).

B(a)P - Benzo(a)pyrene

COPC - Chemical of potential concern

HI - Hazard index

NA - Not applicable

TABLE 6-23

CANCER RISK AND NONCANCER HAZARD RESULTS[a]
SITE FTIR-40 - AREAS 1.1 AND 2
NATIONAL TRAINING CENTER, FORT IRWIN

	Site FTIR-40			
	Area 1.1		Area 2	
Risk Endpoint/Exposure Scenario	**Surface Soil**	**Subsurface Soil**	**Surface Soil**	**Subsurface Soil**
Total Cancer Risk				
Hypothetical Future Resident	2.7E-05	2.5E-05	2.5E-05	3.1E-05
Future Industrial Worker	5.4E-06	3.7E-06	6.3E-06	7.8E-06
USEPA Acceptable Risk Range[b]:	1.0E-04 - 1.0E-06	1.0E-04 - 1.0E-06	1.0E-04 - 1.0E-06	1.0E-04 - 1.0E-06
Primary COPCs:	Arsenic, Chromium	Arsenic	Arsenic	Arsenic, B(a)P
Total Hazard Index (HI)				
Hypothetical Future Resident	**2.5**	0.32	0.13	0.23
Future Industrial Worker	0.48	0.14	0.02	0.1
USEPA Acceptable Risk Range[b]:	1.0	1.0	1.0	1.0
Primary COPCs:	Antimony, Cadmium, **Copper**	NA	NA	NA

Notes:

Bolding indicates excedence of the risk or hazard criterion.

[a] Refer to 'Appendix H' for receptor-specific and chemical-specific cancer risk and noncancer hazard calculations.

[b] Source: Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions (USEPA, 1991a).

B(a)P - Benzo(a)pyrene
COPC - Chemical of potential concern
HI - Hazard index
NA - Not applicable

TABLE 6-24

HUMAN HEALTH RISK-BASED CLEANUP LEVELS
NATIONAL TRAINING CENTER, FORT IRWIN

Site/Medium/Chemical of Concern	Maximum Concentration[a] (mg/kg)	95% UCL Concentration[b] (mg/kg)	Ft Irwin BUTL Concentration[c] (mg/kg)	Risk-Based Cleanup Level[d] (mg/kg)
FTIR-38 Area 2				
Surface soils				
Lead	6,430	3,753	7.33	**3,475** [e]
FTIR-40 Area 1.1				
Surface soils				
Lead	38,400	na [i]	7.33	**3,475** [e]

Notes:

[a] Maximum concentration detected in the indicated medium.

[b] The 95 percent upper confidence limit on the mean (95% UCL) concentration, as calculated in the Human Health Risk Assessment (HHRA).

[c] The background upper tolerance limit (BUTL) determined for Fort Irwin soils (Parsons, 1996).

[d] Risk-based cleanup level for soils, as presented in the Human Health Risk Assessment (HHRA).

[e] Cleanup level is based on the PRG-99 for lead, as derived from DTSC's *Lead Risk Assessment Spreadsheet - Bloodpb7.xls.*

[i] A meaningful 95% UCL concentration could not be calculated from the dataset.

BUTL - Background upper tolerance limit.

mg/kg - Milligrams per kilogram.

na - Not available.

UCL - Upper confidence limit.

TABLE 7-1

EXPOSURE POINT CONCENTRATIONS FOR SURFACE SOIL
SITE FTIR-38 AREA 2 AND REFERENCE AREA (RF1)
NATIONAL TRAINING CENTER, FORT IRWIN

	Site FTIR-38 Area Surface Soil			Reference Area 1 Surface Soil		
COPEC	**Maximum Concentration (mg/kg)**	**95% Upper Confidence Limit (mg/kg)**	**Selected EPC[a] (mg/kg)**	**Maximum Concentration (mg/kg)**	**95% Upper Confidence Limit (mg/kg)**	**Selected EPC[a] (mg/kg)**
Aluminum	41400	22051	22051	13000	10806	10806
Antimony	16	5	5	2.5	12	**2.5**
Arsenic	12	8.6	8.6	4	3.8	3.8
Barium	235	184	184	135	125	125
Cobalt	17	12	12	9	7.9	7.9
Copper	2750	230	230	16	13	13
Lead	6430	3753	3753	10	9	9
Zinc	345	102	102	38	35	35

Notes:

[a] The lower value of the maximum concentration or the 95% UCL was selected as the EPC Cases where the maximum value was selected are presented in **bold**.

COPEC Chemical of Potential Ecological Concern
EPC Exposure Point Concentration

TABLE 7-2

EXPOSURE POINT CONCENTRATIONS FOR PLANTS
SITE FTIR-38 AREA 2 AND REFERENCE AREA (RF1)
NATIONAL TRAINING CENTER, FORT IRWIN

	Site FTIR-38 Area 2 Plants			Reference Area 1 Plants		
COPEC	Maximum Concentration (mg/kg)	95% Upper Confidence Limit (mg/kg)	Selected EPC[a] (mg/kg)	Maximum Concentration (mg/kg)	95% Upper Confidence Limit (mg/kg)	Selected EPC[a] (mg/kg)
Aluminum	129	126	126	287	435	**287**
Antimony	2.5	6	**2.5**	2.5	59	**2.5**
Arsenic	0.2	0.1	0.1	0.3	0.2	0.2
Barium	32	16.6	16.6	23	17	17
Cobalt	0.3	0.25	0.25	0.3	0.2	0.2
Copper	4	3	3	3	2	2
Lead	1	0.8	0.8	1	0.5	0.5
Zinc	11	8	8	10	9	9

Notes:

[a] The lower value of the maximum concentration or the 95% UCL was selected as the EPC. Cases where the maximum value was selected are presented in **bold**.

COPEC Chemical of Potential Ecological Concern
EPC Exposure Point Concentration

TABLE 7-3

EXPOSURE POINT CONCENTRATIONS FOR SURFACE SOIL
SITE FTIR-40 AREA 1.1 AND REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

	Site FTIR-40 Area 1.1 Surface Soil			Reference Area 2 Surface Soil [b]		
COPEC	Maximum Concentration (mg/kg)	95% Upper Confidence Limit (mg/kg)	Selected EPC[a] (mg/kg)	Maximum Concentration (mg/kg)	95% Upper Confidence Limit (mg/kg)	Selected EPC[a] (mg/kg)
Aluminum	34700	19202	19202	15200	13075	13075
Antimony	94	36	36	2	3	**2**
Arsenic	26	10	10	11	8	8
Barium	1230	405	405	194	181	181
Cadmium	54	77	**54**	0 2	0.2	0 2
Chromium	94	32	32	16	13	13
Cobalt	19	11	11	10	8 6	8.6
Copper	12900	12069	12069	22	18	18
Lead	38400	566344	**38400**	13	12	12
Manganese	1380	714	714	422	388	388
Nickel	79	33	33	16	13	13
Selenium	1	0.9	0.9	1	1	1
Silver	74	75	**74**	1	1	1
Zinc	8740	14768	**8740**	64	53	53

Notes:

[a] The lower value of the maximum concentration or the 95% UCL was selected as the EPC. Cases where the maximum value was selected are presented in **bold**.
[b] Reference Area 2 corresponds to both Site 40 Area 1 1 and Site 40 Area 2. The data presented The data presented herein are the same as the data presented in Table 7-5

COPEC Chemical of Potential Ecological Concern
EPC Exposure Point Concentration

TABLE 7-4

EXPOSURE POINT CONCENTRATIONS FOR PLANTS
SITE FTIR-40 AREA 1.1 AND
REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

	Site FTIR-40 Area 1.1 Plants			Reference Area 2 Plants[b]		
COPEC	Maximum Concentration (mg/kg)	95% Upper Confidence Limit (mg/kg)	Selected EPC[a] (mg/kg)	Maximum Concentration (mg/kg)	95% Upper Confidence Limit (mg/kg)	Selected EPC[a] (mg/kg)
Aluminum	53	38	38	61	55	55
Antimony	2.5	12	**2.5**	2.5	9	**2.5**
Arsenic	0.15	0.16	**0.15**	0.2	0.15	0.15
Barium	28	22	22	37.5	37.6	**37.5**
Cadmium	1	0.4	0.4	0.1	0.1	0.1
Chromium	2	1.5	1.5	2	1	1
Cobalt	0.25	0.27	**0.25**	0.3	0.25	0.25
Copper	7	4	4	3	2	2
Lead	1	0.45	0.45	1	0.3	0.3
Manganese	28	24	24	27	21	21
Nickel	2	0.98	0.98	0.5	0.3	0.3
Selenium	1	0.4	0.4	0.4	0.3	0.3
Silver	0.3	0.25	0.25	0.3	0.25	0.25
Zinc	53	29	29	4	3.6	3.6

Notes:

[a] The lower value of the maximum concentration or the 95% UCL was selected as the EPC. Cases where the maximum value was selected are presented in **bold**.

[b] Reference Area 2 corresponds to both Site 40 Area 1.1 and Site 40 Area 2. The data presented The data presented herein are the same as the data presented in Table 7-6.

COPEC Chemical of Potential Ecological Concern

EPC Exposure Point Concentration

TABLE 7-5

EXPOSURE POINT CONCENTRATIONS FOR SURFACE SOIL
SITE FTIR-40 AREA 2 AND REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

	Site FTIR-40 Area 2 Surface Soil			Reference Area 2 Surface Soil [b]		
COPEC	Maximum Concentration (mg/kg)	95% Upper Confidence Limit (mg/kg)	Selected EPC[a] (mg/kg)	Maximum Concentration (mg/kg)	95% Upper Confidence Limit (mg/kg)	Selected EPC[a] (mg/kg)
Arsenic	11	9 8	9 8	11	8	8
Cadmium	0.5	0.35	0 35	0 2	0.2	0.2
Lead	259	82	82	13	12	12
Zinc	213	101	101	64	53	53

Notes:

[a] The lower value of the maximum concentration or the 95% UCL was selected as the EPC Cases where the maximum value was selected are presented in **bold**.

[b] Reference Area 2 corresponds to both Site 40 Area 1 1 and Site 40 Area 2 The data presented The data presented herein are the same as the data presented in Table 7-3

COPEC Chemical of Potential Ecological Concern
EPC Exposure Point Concentration

TABLE 7-6

EXPOSURE POINT CONCENTRATIONS FOR PLANTS
SITE FTIR-40 AREA 2 AND REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

COPEC	Site FTIR-40 Area 2 Plants: Maximum Concentration (mg/kg)	Site FTIR-40 Area 2 Plants: 95% Upper Confidence Limit (mg/kg)	Site FTIR-40 Area 2 Plants: Selected EPC[a] (mg/kg)	Reference Area 2 Plants[b]: Maximum Concentration (mg/kg)	Reference Area 2 Plants[b]: 95% Upper Confidence Limit (mg/kg)	Reference Area 2 Plants[b]: Selected EPC[a] (mg/kg)
Arsenic	0.2	0.15	0.15	0.2	0.15	0.15
Cadmium	0.3	0.15	0.15	0.1	0.1	0.1
Lead	0.5	0.46	0.46	0.6	0.3	0.3
Zinc	22	17.9	17.9	4	3.6	3.6

Notes:

[a] The lower value of the maximum concentration or the 95% UCL was selected as the EPC. Cases where the maximum value was selected are presented in **bold**.
[b] Reference Area 2 corresponds to both Site 40 Area 1.1 and Site 40 Area 2. The data presented The data presented herein are the same as the data presented in Table 7-4

COPEC Chemical of Potential Ecological Concern
EPC Exposure Point Concentration

TABLE 7-7

EXPOSURE PARAMETERS FOR THE MOJAVE GROUND SQUIRREL
NATIONAL TRAINING CENTER, FORT IRWIN

Exposure Parameter	Exposure Value	Source
Body Weight (BW):		
Average[a]	0.108 Kg	Whittaker, 1997; 1996
Range[b]	0 085-0 130 Kg	
Diet Composition:		
Plant Matter	100 %	Zeiner et. al , 1990
Food Ingestion Rate (IR_{plant}):		
Plant Matter	0 0174 Kg/day	US EPA, 1993; Equation 3-9
Soil Ingestion Rate (IR_{soil})[c]:		
Percent of diet	2.4 %	US EPA, 1993
Daily intake[d]	0 0004 Kg/day	
Skin Surface Area (SSA):		
Whole body	258 cm^2	US EPA, 1993; Equation 3-22
Exposed[e]	10 3 cm^2	
Home Range (HR)[f]	0 9 acres	Ziener et al, 1990
Exposure Area (EA)[g]:		
FTIR 38-2	27 6 acres	Site-specific
FTIR 40-1	2.8 acres	
FTIR 40-2	5 5 acres	
Site Utilization Factor (SUF)[h]:		
FTIR 38-2	1 unitless	Site-specific
FTIR 40-1	1 unitless	
FTIR 40-2	1 unitless	
Exposure Duration (ED)[i]	0 5 unitless	Site-specific
Dermal Absorption Factor (ABS)	0 1 organic chemicals 0 01 inorganic chemicals	US EPA, 1992b
Soil Adherence Factor (AF)	0.2 mg/cm^2-d	US EPA, 1992b

Notes:

[a] Average body weight for males and females combined; value used in calculations
[b] Range of body weights for males and females
[c] Mohave ground squirrel injestion rates are based on meadow vole soil ingestion rates
[d] Calculated as percent soil ingestion rate multiplied by the food ingestion rate.
[e] Exposed skin surface area was calculated assuming the area of the feet (4% of total skin surface area)
[f] Home range is equal to the area necessary to support the dietary and reproductive needs of each animal
[g] Exposure area based on the total area of each site
[h] Site utilization factors are calculated as the exposure area divided by the home range: SUF = EA/HR
[i] Exposure duration (i e , percent of year exposed) for the Mohave ground squirrel equal to 0 5 because the species estivates from August to March

cm^2 - Square centimeters
Kg/day - Kilograms per day
mg/cm^2-d - Milligrams per square centimeters per day

TABLE 7-8

ECOLOGICAL TOXICITY REFERENCE VALUES
FOR THE MOJAVE GROUND SQUIRREL -- ARMY VALUES
NATIONAL TRAINING CENTER, FORT IRWIN

COPEC	Army Toxicity Benchmark [a] (mg/kg-d)	Benchmark Species	Benchmark Species Body Weight (kg)	Allometric Toxicity Reference Value - IRV_{Army} [b] (mg/kg-d)
Inorganics				
Aluminum	1.93E+00	Mouse	0.030	1.4E+00
Antimony	1.25E-01	Mouse	0.030	9.1E-02
Arsenic	1.26E-01	Mouse	0.030	9.1E-02
Barium	5.06E+00	Rat	0.35	6.8E+00
Cadmium	1.90E-01	Rat	0.35	2.5E-01
Chromium	3.28E+00	Rat	0.35	4.4E+00
Cobalt	--	--	--	--
Copper	1.17E+01	Mink	1.0	2.0E+01
Lead [c]	1.50E+00	various	--	1.5E+00
Manganese	8.80E+01	Rat	0.35	1.2E+02
Nickel	4.00E+01	Rat	0.35	5.4E+01
Selenium	7.50E-02	Mouse	0.030	5.4E-02
Silver	--	--	--	--
Zinc	1.60E+02	Rat	0.35	2.1E+02

Notes:

[a] Toxicity benchmarks were obtained from Sample et al. (1996), unless otherwise specified

[b] Mojave Ground Squirrel toxicity reference values are derived from body weight-based allometric conversion of the toxicity benchmark value using the following equation:

$$Dose_{squirrel} = Dose_{test\ organism} (Body\ Weight_{test\ organism} / Body\ Weight_{squirrel})^{0.25}$$

Where the body weight of the Mojave Ground Sqirrel is 0.108 kg

[c] Army mammalian IRV for lead (USAEC, 2001).

COPEC - Chemical of potential ecological concern
kg - Kilograms
mg/kg-d - Milligrams per kilogram body weight per day
-- Not Available or Not Applicable
IRV - Toxicity reference value

TABLE 7-9A

ECOLOGICAL TOXICITY REFERENCE VALUES
FOR THE MOJAVE GROUND SQUIRREL --
BIOLOGICAL TOXICITY ADVISORY GROUP (BTAG) VALUES
NATIONAL TRAINING CENTER, FORT IRWIN

COPEC	BTAG--Low Benchmark [a] (mg/kg-d)	Benchmark Species	Benchmark Species Body Weight (kg)	Allometric Toxicity Reference Value BTAG TRV_{Low} [b] (mg/kg-d)
Aluminum	--	--	--	--
Antimony	--	--	--	--
Arsenic	3 20E-01	rat	0 332	4 2E-01
Barium	--	--	--	--
Cadmium	6 00E-02	mouse	0.0322	4 4E-02
Chromium	--	--	--	--
Cobalt	1 20E+00	rat	0.275	1 5E+00
Copper	2.67E+00	mouse	0 03	1 9E+00
Lead	1.50E-03	rat	0 208	1.8E-03
Manganese	1.37E+01	mouse	0 0346	1.0E+01
Nickel	1 33E-01	rat	0.2486	1 6E-01
Selenium[c]	5 00E-02	rat	0.246	6.1E-02
Silver	--	--	--	--
Zinc	9 60E+00	mouse	0.0255	6 7E+00

Notes:

[a] BTAG Low and High Toxicity Reference Values and test organism weights were obtained from EFA, West (1998)

[b] Mojave Ground Squirrel toxicity reference values are derived from body weight-based allometric conversion of the toxicity benchmark value using the following equation:

$$\text{Dose}_{\text{squirrel}} = \text{Dose}_{\text{test organism}} (\text{Body Weight}_{\text{test organism}} / \text{Body Weight}_{\text{squirrel}})^{0\ 25}$$

Where the body weight of the Mojave Ground Sqirrel is 0 108 kg

[c] In EFA, West (1998), the selenium low TRV test organism weight given for a rat was the same as the weight given for a mouse The weight used herein has been modified to make it consistent with the rat's weight

COPEC - Chemical of potential ecological concern

kg - Kilograms

mg/kg-d - Milligrams per kilogram body weight per day

-- Not Available or Not Applicable

TRV - Toxicity reference value

TABLE 7-9B

ECOLOGICAL TOXICITY REFERENCE VALUES
FOR THE MOJAVE GROUND SQUIRREL –
BIOLOGICAL TOXICITY ADVISORY GROUP (BTAG) VALUES
NATIONAL TRAINING CENTER, FORT IRWIN

COPEC	BTAG--High Benchmark [a] (mg/kg-d)	Benchmark Species	Benchmark Species Body Weight (kg)	Allometric Toxicity Reference Value BTAG TRV_{High} [b] (mg/kg-d)
Aluminum	--	--	--	--
Antimony	--	--	--	--
Arsenic	4.70E+00	rat	0.11	4.7E+00
Barium	--	--	--	--
Cadmium	2.64E+00	mouse	0.03141	1.9E+00
Chromium	--	--	--	--
Cobalt	2.00E+01	rat	0.2	2.3E+01
Copper	6.32E+02	mouse	0.0247	4.4E+02
Lead	2.41E+02	mouse	0.0187	1.6E+02
Manganese	1.59E+02	mouse	0.0297	1.2E+02
Nickel	3.16E+01	rat	0.2486	3.9E+01
Selenium[c]	1.21E+00	mouse	0.0246	8.4E-01
Silver	--	--	--	--
Zinc	4.11E+02	rat	0.175	4.6E+02

Notes:

[a] BTAG Low and High Toxicity Reference Values and test organism weights were obtained from EFA, West (1998)

[b] Mojave Ground Squirrel toxicity reference values are derived from body weight-based allometric conversion of the toxicity benchmark value using the following equation:

$$Dose_{squirrel} = Dose_{test\ organism}\ (Body\ Weight_{test\ organism} / Body\ Weight_{squirrel})^{0.25}$$

Where the body weight of the Mojave Ground Sqirrel is 0.108 kg

[c] In EFA, West (1998), the selenium low TRV test organism weight given for a rat was the same as the weight given for a mouse. The weight used herein has been modified to make it consistent with the rat's weight

COPEC - Chemical of potential ecological concern

kg - Kilograms

mg/kg-d - Milligrams per kilogram body weight per day

-- Not Available or Not Applicable

TRV - Toxicity reference value

TABLE 7-10

DOSE AND HAZARD QUOTIENT CALCULATIONS USING ARMY TRVs SITE FTIR-38 AREA 2 AND REFERENCE AREA (RF1) NATIONAL TRAINING CENTER, FORT IRWIN

(Page 1 of 2)

COPEC	Exposure Point Concentration (EPC) EPC$_{Soil}$ [a] (mg/kg)	EPC$_{Plant}$ [b] (mg/kg)	Food Ingestion Dose$_{food}$ [c] (mg/kg-day)	Incidental Soil Ingestion Dose$_{soil}$ [d] (mg/kg-day)	Dermal Exposure Dose$_{dermal}$ [e] (mg/kg-day)	Total Exposure Dose$_{total}$ [f] (mg/kg-day)	Army TRV$_{Army}$ [g] (mg/kg-day)	HQ [h] (unitless)
Site FTIR-38 Area 2								
Aluminum	2.21E+04	1.26E+02	1.01E+01	4.08E+01	2.1E-03	5.1E+01	1.4E+00	36
Antimony	5.50E+00	**2.50E+00**	2.01E-01	1.02E-02	5.2E-07	2.1E-01	9.1E-02	2.3
Arsenic	8.55E+00	1.46E-01	1.17E-02	1.58E-02	8.2E-07	2.8E-02	9.1E-02	0.3
Barium	1.84E+02	1.66E+01	1.34E+00	3.40E-01	1.8E-05	1.7E+00	6.8E+00	0.2
Cobalt	1.22E+01	2.54E-01	2.05E-02	2.25E-02	1.2E-06	4.3E-02	--	--
Copper	2.30E+02	3.20E+00	2.58E-01	4.25E-01	2.2E-05	6.8E-01	2.0E+01	0.03
Lead	3.75E+03	8.01E-01	1.29E-02	1.39E+00	3.6E-04	1.4E+00	1.5E+00	0.9
Zinc	1.02E+02	8.27E+00	6.66E-01	1.89E-01	9.7E-06	8.6E-01	2.1E+02	0.004
							Hazard Index: [i]	40
Site FTIR-38 Reference Area 1								
Aluminum	1.08E+04	**2.87E+02**	2.31E+01	2.00E+01	1.0E-03	4.3E+01	1.4E+00	30.8
Antimony	**2.55E+00**	**2.50E+00**	2.01E-01	4.72E-03	2.4E-07	2.1E-01	9.1E-02	2.3
Arsenic	3.82E+00	2.04E-01	1.65E-02	7.07E-03	3.6E-07	2.4E-02	9.1E-02	0.3
Barium	1.25E+02	1.70E+01	1.37E+00	2.31E-01	1.2E-05	1.6E+00	6.8E+00	0.2
Cobalt	7.91E+00	2.35E-01	1.89E-02	1.46E-02	7.5E-07	3.4E-02	--	--
Copper	1.35E+01	2.18E+00	1.76E-01	2.50E-02	1.3E-06	2.0E-01	2.0E+01	0.01
Lead	9.38E+00	4.96E-01	7.99E-03	3.47E-03	8.9E-07	1.1E-02	1.5E+00	0.008
Zinc	3.51E+01	9.26E+00	7.46E-01	6.49E-02	3.3E-06	8.1E-01	2.1E+02	0.004
							Hazard Index: [i]	34

TABLE 7-10

DOSE AND HAZARD QUOTIENT CALCULATIONS USING ARMY TRVs
SITE FTIR-38 AREA 2 AND REFERENCE AREA (RF1)
NATIONAL TRAINING CENTER, FORT IRWIN

COPEC	Exposure Point Concentration (EPC) EPC_{Soil} [a] (mg/kg)	EPC_{Plant} [b] (mg/kg)	Food Ingestion $Dose_{food}$ [c] (mg/kg-day)	Incidental Soil Ingestion $Dose_{soil}$ [d] (mg/kg-day)	Dermal Exposure $Dose_{dermal}$ [e] (mg/kg-day)	Total Exposure $Dose_{total}$ [f] (mg/kg-day)	Army TRV_{Army} [g] (mg/kg-day)	HQ [h] (unitless)

Notes:

[a] 95% UCL or maximum concentration in surface soil (0 - 1 foot bgs). Maximum concentrations in **bold** (See Table 7-1).

[b] Dietary exposure point concentration is the 95% UCL or maximum of measured concentration in dietary items (plants). Maximum values in **bold** (See Table 7-2).

[c] $Dose_{food} = EPC_{soil} \times IR_{plant}$
where: IR_{plant} - Injestion rate of plants from Table 7-7.

[d] $Dose_{soil} = EPC_{soil} \times IR_{soil} \times ED \times SUF$
where: IR_{soil} - Injestion rate of soil from Table 7-7.
ED - Exposure Duration from Table 7-7.
SUF - Site Utilization Factor from Table 7-7.

[e] $Dose_{dermal} = (EPC_{soil} \times SSA \times AF \times ABS \times ED \times SUF)/BW$
where: SSA - Skin Surface Area from Table 7-7.
AF - soil adherance factor from Table 7-7.
ABS - the dermal absorption factor from Table 7-7.
SUF - Site Utilization Factor from Table 7-7.
BW - Mojave Ground Squirrel's Body Weight from Table 7-7

[f] $Dose_{total} = Dose_{food} + Dose_{soil} + Dose_{dermal}$

[g] Army Toxicity Reference Values (TRV_{Army}) were presented in Table 7-8.

[h] $HQ = Dose_{total}/TRV_{Army}$

[i] The hazard index is defined as the sum of the individual hazard quotients.

COPEC - Chemical of potential ecological concern
EPC - Exposure Point Concentration
HQ -Hazard Quotient
TRV - Toxicity Reference Value

TABLE 7-11

**DOSE AND HAZARD QUOTIENT CALCULATIONS USING BTAG TRVs
SITE FTIR-38 AREA 2 AND REFERENCE AREA (RF1)
NATIONAL TRAINING CENTER, FORT IRWIN**

COPEC	Exposure Point Concentration (EPC) EPC_{Soil} [a] (mg/kg)	EPC_{Plant} [b] (mg/kg)	Food Ingestion $Dose_{food}$ [c] (mg/kg-day)	Incidental Soil Ingestion $Dose_{soil}$ [d] (mg/kg-day)	Dermal Exposure $Dose_{dermal}$ [e] (mg/kg-day)	Total Exposure $Dose_{total}$ [f] (mg/kg-day)	BTAG TRV_{Low} [g] (mg/kg-day)	HQ [h] (unitless)	BTAG TRV_{High} [i] (mg/kg-day)	HQ (unitless)
Site FTIR-38 Area 2										
Aluminum	2.21E+04	1.26E+02	1.01E+01	4.08E+01	2.1E-03	5.1E+01	--	--	--	--
Antimony	5.50E+00	**2.50E+00**	2.01E-01	1.02E-02	5.2E-07	2.1E-01	--	--	--	--
Arsenic	8.55E+00	1.46E-01	1.17E-02	1.58E-02	8.2E-07	2.8E-02	4.2E-01	0.07	4.7E+00	0.01
Barium	1.84E+02	1.66E+01	1.34E+00	3.40E-01	1.8E-05	1.7E+00	--	--	--	--
Cobalt	1.22E+01	2.54E-01	2.05E-02	2.25E-02	1.2E-06	4.3E-02	1.52E+00	0.03	2.33E+01	0.002
Copper	2.30E+02	3.20E+00	2.58E-01	4.25E-01	2.2E-05	6.8E-01	1.9E+00	0.35	4.4E+02	0.0016
Lead	3.75E+03	8.01E-01	1.29E-02	1.39E+00	3.6E-04	1.4E+00	1.8E-03	794	1.6E+02	0.01
Zinc	1.02E+02	8.27E+00	6.66E-01	1.89E-01	9.7E-06	8.6E-01	6.69E+00	0.13	4.64E+02	0.002
							Hazard Index:	795	Hazard Index:	0.02
Site FTIR-38 Reference Area 1										
Aluminum	1.08E+04	**2.87E+02**	2.31E+01	2.00E+01	1.0E-03	4.3E+01	--	--	--	--
Antimony	**2.55E+00**	**2.50E+00**	2.01E-01	4.72E-03	2.4E-07	2.1E-01	--	--	--	--
Arsenic	3.82E+00	2.04E-01	1.65E-02	7.07E-03	3.6E-07	2.4E-02	4.24E-01	0.06	4.72E+00	0.005
Barium	1.25E+02	1.70E+01	1.37E+00	2.31E-01	1.2E-05	1.6E+00	--	--	--	--
Cobalt	7.91E+00	2.35E-01	1.89E-02	1.46E-02	7.5E-07	3.4E-02	1.52E+00	0.02	2.33E+01	0.001
Copper	1.35E+01	2.18E+00	1.76E-01	2.50E-02	1.3E-06	2.0E-01	1.94E+00	0.10	4.37E+02	0.0005
Lead	9.38E+00	4.96E-01	7.99E-03	3.47E-03	8.9E-07	1.1E-02	1.77E-03	6	1.55E+02	0.0001
Zinc	3.51E+01	9.26E+00	7.46E-01	6.49E-02	3.3E-06	8.1E-01	6.69E+00	0.12	4.64E+02	0.002
							Hazard Index:	7	Hazard Index:	0.01

TABLE 7-11

DOSE AND HAZARD QUOTIENT CALCULATIONS USING BTAG TRVs SITE FTIR-38 AREA 2 AND REFERENCE AREA (RF1) NATIONAL TRAINING CENTER, FORT IRWIN

	Exposure Point Concentration (EPC)		Food Ingestion	Incidental Soil Ingestion	Dermal Exposure	Total Exposure	BTAG		BTAG	
COPEC	EPC_{Soil} [a] (mg/kg)	EPC_{Plant} [b] (mg/kg)	$Dose_{food}$ [c] (mg/kg-day)	$Dose_{soil}$ [d] (mg/kg-day)	$Dose_{dermal}$ [e] (mg/kg-day)	$Dose_{total}$ [f] (mg/kg-day)	TRV_{Low} [g] (mg/kg-day)	HQ [h] (unitless)	TRV_{High} [i] (mg/kg-day)	HQ (unitless)

Notes:

[a] 95% UCL or maximum concentration in surface soil (0 - 1 foot bgs). Maximum concentrations in **bold** (See Table 7-1).
[b] Dietary exposure point concentration is the 95% UCL or maximum of measured concentration in dietary items (plants). Maximum values in **bold** (See Table 7-2).
[c] $Dose_{food} = EPC_{soil} \times IR_{plant}$
where: IR_{plant} - Injestion rate of plants from Table 7-7.
[d] $Dose_{soil} = EPC_{soil} \times IR_{soil} \times ED \times SUF$
where: IR_{soil} - Injestion rate of soil from Table 7-7.
ED - Exposure Duration from Table 7-7.
SUF - Site Utilization Factor from Table 7-7.
[e] $Dose_{dermal} = (EPC_{soil} \times SSA \times AF \times ABS \times ED \times SUF)/BW$
where: SSA - Skin Surface Area from Table 7-7.
AF - soil adherance factor from Table 7-7.
ABS - the dermal absorption factor from Table 7-7.
SUF - Site Utilization Factor from Table 7-7.
BW - Mojave Ground Squirrel's Body Weight from Table 7-7.
[f] $Dose_{total} = Dose_{food} + Dose_{soil} + Dose_{dermal}$
[g] BTAG TRV_{low} and BTAG TRV_{high} were presented in Table 7-9a and 7-7b.
[h] $HQ = Dose_{total}/TRV_{Army}$
[i] The hazard index is defined as the sum of the individual hazard quotients.

COPEC - Chemical of potential ecological concern
EPC - Exposure Point Concentration
HQ -Hazard Quotient
TRV - Toxicity Reference Value

TABLE 7-12

DOSE AND HAZARD QUOTIENT CALCULATIONS USING ARMY TRVs
SITE FTIR-40 AREA 1 AND REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

COPEC	Exposure Point Concentration (EPC) EPC_{Soil} [a] (mg/kg)	EPC_{Plant} [b] (mg/kg)	Food Ingestion $Dose_{food}$ [c] (mg/kg-day)	Incidental Soil Ingestion $Dose_{soil}$ [d] (mg/kg-day)	Dermal Exposure $Dose_{dermal}$ [e] (mg/kg-day)	Total Exposure $Dose_{total}$ [f] (mg/kg-day)	Army TRV_{Army} [g] (mg/kg-day)	HQ [h] (unitless)
Site FTIR-40 Area 1								
Aluminum	1.92E+04	3.80E+01	3.06E+00	3.56E+01	1.8E-03	3.9E+01	1.4E+00	28
Antimony	3.61E+01	**2.50E+00**	2.01E-01	6.68E-02	3.4E-06	2.7E-01	9.1E-02	3
Arsenic	1.03E+01	**1.50E-01**	1.21E-02	1.90E-02	9.8E-07	3.1E-02	9.1E-02	0.3
Barium	4.05E+02	2.20E+01	1.77E+00	7.49E-01	3.9E-05	2.5E+00	6.8E+00	0.4
Cadmium	**5.4E+01**	4.00E-01	3.22E-02	9.98E-02	5.1E-06	1.3E-01	2.5E-01	0.5
Chromium	3.19E+01	1.53E+00	1.23E-01	5.91E-02	3.0E-06	1.8E-01	4.4E+00	0.04
Cobalt	1.06E+01	**2.50E-01**	2.01E-02	1.96E-02	1.0E-06	4.0E-02	--	--
Copper	1.21E+04	4.00E+00	3.22E-01	2.23E+01	1.2E-03	2.3E+01	2.0E+01	1.1
Lead	**3.8E+04**	4.50E-01	7.25E-03	1.42E+01	3.7E-03	1.4E+01	1.5E+00	9
Manganese	7.14E+02	2.37E+01	1.91E+00	1.32E+00	6.8E-05	3.2E+00	1.2E+02	0.03
Nickel	3.26E+01	9.77E-01	7.87E-02	6.03E-02	3.1E-06	1.4E-01	5.4E+01	0.003
Selenium	9.40E-01	4.02E-01	3.24E-02	1.74E-03	9.0E-08	3.4E-02	5.4E-02	0.6
Silver	**7.40E+01**	2.50E-01	2.01E-02	1.37E-01	7.1E-06	1.6E-01	--	--
Zinc	**8.74E+03**	2.93E+01	2.36E+00	1.62E+01	8.3E-04	1.9E+01	2.1E+02	0.1
							Hazard Index:	43
Site FTIR-40 Reference Area 1								
Aluminum	1.31E+04	5.49E+01	4.42E+00	2.42E+01	1.2E-03	2.9E+01	1.4E+00	20
Antimony	**2.10E+00**	**2.50E+00**	2.01E-01	3.89E-03	2.0E-07	2.1E-01	9.1E-02	2.3
Arsenic	8.12E+00	1.50E-01	1.21E-02	1.50E-02	7.7E-07	2.7E-02	9.1E-02	0.3
Barium	1.81E+02	**3.75E+01**	3.02E+00	3.35E-01	1.7E-05	3.4E+00	6.8E+00	0.5
Cadmium	2.05E-01	**1.00E-01**	8.06E-03	3.80E-04	2.0E-08	8.4E-03	2.5E-01	0.03

TABLE 7-12

DOSE AND HAZARD QUOTIENT CALCULATIONS USING ARMY TRVs
SITE FTIR-40 AREA 1 AND REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

COPEC	Exposure Point Concentration (EPC) EPC$_{Soil}$ [a] (mg/kg)	EPC$_{Plant}$ [b] (mg/kg)	Food Ingestion Dose$_{food}$ [c] (mg/kg-day)	Incidental Soil Ingestion Dose$_{soil}$ [d] (mg/kg-day)	Dermal Exposure Dose$_{dermal}$ [e] (mg/kg-day)	Total Exposure Dose$_{total}$ [f] (mg/kg-day)	Army TRV$_{Army}$ [g] (mg/kg-day)	HQ [h] (unitless)
Site FTIR-40 Reference Area 2 (cont'd)								
Chromium	1.32E+01	1.39E+00	1.12E-01	2.45E-02	1.3E-06	1.4E-01	4.4E+00	0.03
Cobalt	8.58E+00	2.50E-01	2.01E-02	1.59E-02	8.2E-07	3.6E-02	--	--
Copper	1.82E+01	2.02E+00	1.63E-01	3.36E-02	1.7E-06	2.0E-01	2.0E+01	0.01
Lead	1.19E+01	3.47E-01	5.59E-03	4.41E-03	1.1E-06	1.0E-02	1.5E+00	0.007
Manganese	3.88E+02	2.07E+01	1.67E+00	7.19E-01	3.7E-05	2.4E+00	1.2E+02	0.02
Nickel	1.32E+01	3.09E-01	2.49E-02	2.44E-02	1.3E-06	4.9E-02	5.4E+01	0.001
Selenium	1.08E+00	3.44E-01	2.77E-02	2.01E-03	1.0E-07	3.0E-02	5.4E-02	0.5
Silver	1.04E+00	2.50E-01	2.01E-02	1.93E-03	9.9E-08	2.2E-02	--	--
Zinc	5.35E+01	3.64E+00	2.93E-01	9.90E-02	5.1E-06	3.9E-01	2.1E+02	0.002
							Hazard Index:	24

Notes:

[a] 95% UCL or maximum concentration in surface soil (0 - 1 foot bgs). Maximum concentrations in **bold** (See Table 7-3).

[b] Dietary exposure point concentration is the 95% UCL or maximum of measured concentration in dietary items (plants). Maximum values in **bold** (See Table 7-4).

[c] $Dose_{food} = EPC_{soil} \times IR_{plant}$

where: IR_{plant} - Injestion rate of plants from Table 7-7.

[d] $Dose_{soil} = EPC_{soil} \times IR_{soil} \times ED \times SUF$

where: IR_{soil} - Injestion rate of soil from Table 7-7.

ED - Exposure Duration from Table 7-7.

SUF - Site Utilization Factor from Table 7-7.

TABLE 7-12

DOSE AND HAZARD QUOTIENT CALCULATIONS USING ARMY TRVs
SITE FTIR-40 AREA 1 AND REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

	Exposure Point Concentration (EPC)		Food Ingestion	Incidental Soil Ingestion	Dermal Exposure	Total Exposure	Army	
COPEC	EPC_{Soil} [a] (mg/kg)	EPC_{Plant} [b] (mg/kg)	$Dose_{food}$ [c] (mg/kg-day)	$Dose_{soil}$ [d] (mg/kg-day)	$Dose_{dermal}$ [e] (mg/kg-day)	$Dose_{total}$ [f] (mg/kg-day)	TRV_{Army} [g] (mg/kg-day)	HQ [h] (unitless)

[e] $Dose_{dermal} = (EPC_{soil} \times SSA \times AF \times ABS \times ED \times SUF)/BW$
where: SSA - Skin Surface Area from Table 7-7.
AF - soil adherance factor from Table 7-7.
ABS - the dermal absorption factor from Table 7-7.
SUF - Site Utilization Factor from Table 7-7.
BW - Mojave Ground Squirrel's Body Weight from Table 7-7

[f] $Dose_{total} = Dose_{food} + Dose_{soil} + Dose_{dermal}$

[g] Army Toxicity Reference Values (TRV_{Army}) were presented in Table 7-8.

[h] $HQ = Dose_{total}/TRV_{Army}$

[i] The hazard index is defined as the sum of the individual hazard quotients.

COPEC - Chemical of potential ecological concern
EPC - Exposure Point Concentration
HQ -Hazard Quotient
TRV - Toxicity Reference Value

TABLE 7-13

DOSE AND HAZARD QUOTIENT CALCULATIONS USING BTAG TRVs
SITE FTIR-40 AREA 1 AND REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 1 of 2)

COPEC	Exposure Point Concentration (EPC) EPC_{Soil} [a] (mg/kg)	EPC_{Plant} [b] (mg/kg)	Food Ingestion $Dose_{food}$ [c] (mg/kg-day)	Incidental Soil Ingestion $Dose_{soil}$ [d] (mg/kg-day)	Dermal Exposure $Dose_{dermal}$ [e] (mg/kg-day)	Total Exposure $Dose_{total}$ [f] (mg/kg-day)	BTAG TRV_{Low} [g] (mg/kg-day)	HQ [h] (unitless)	BTAG TRV_{High} [i] (mg/kg-day)	HQ (unitless)
Site FTIR-40 Area 1.1										
Aluminum	1.92E+04	3.80E+01	3.06E+00	3.56E+01	1.8E-03	3.9E+01	--	--	--	--
Antimony	3.61E+01	**2.50E+00**	2.01E-01	6.68E-02	3.4E-06	2.7E-01	--	--	--	--
Arsenic	1.03E+01	**1.50E-01**	1.21E-02	1.90E-02	9.8E-07	3.1E-02	4.24E-01	0.07	4.72E+00	0.01
Barium	4.05E+02	2.20E+01	1.77E+00	7.49E-01	3.9E-05	2.5E+00	--	--	--	--
Cadmium	**5.4E+01**	4.00E-01	3.22E-02	9.98E-02	5.1E-06	1.3E-01	4.43E-02	3	1.94E+00	0.07
Chromium	3.19E+01	1.53E+00	1.23E-01	5.91E-02	3.0E-06	1.8E-01	--	--	--	--
Cobalt	1.06E+01	**2.50E-01**	2.01E-02	1.96E-02	1.0E-06	4.0E-02	1.52E+00	0.03	2.33E+01	0.002
Copper	1.21E+04	4.00E+00	3.22E-01	2.23E+01	1.2E-03	2.3E+01	1.94E+00	12	4.37E+02	0.05
Lead	**3.8E+04**	4.50E-01	7.25E-03	1.42E+01	3.7E-03	1.4E+01	1.77E-03	8055	1.55E+02	0.09
Manganese	7.14E+02	2.37E+01	1.91E+00	1.32E+00	6.8E-05	3.2E+00	1.03E+01	0.3	1.15E+02	0.03
Nickel	3.26E+01	9.77E-01	7.87E-02	6.03E-02	3.1E-06	1.4E-01	1.64E-01	0.8	3.89E+01	0.004
Selenium	9.40E-01	4.02E-01	3.24E-02	1.74E-03	9.0E-08	3.4E-02	6.14E-02	0.6	8.36E-01	0.04
Silver	**7.40E+01**	2.50E-01	2.01E-02	1.37E-01	7.1E-06	1.6E-01	--	--	--	--
Zinc	**8.74E+03**	2.93E+01	2.36E+00	1.62E+01	8.3E-04	1.9E+01	6.69E+00	3	4.64E+02	0.04
							Hazard Index:	8074	Hazard Index:	0.3
Site FTIR-40 Reference Area 2										
Aluminum	1.31E+04	5.49E+01	4.42E+00	2.42E+01	1.2E-03	2.9E+01	--	--	--	--
Antimony	**2.10E+00**	**2.50E+00**	2.01E-01	3.89E-03	2.0E-07	2.1E-01	--	--	--	--
Arsenic	8.12E+00	1.50E-01	1.21E-02	1.50E-02	7.7E-07	2.7E-02	4.24E-01	0.06	4.72E+00	0.01
Barium	1.81E+02	**3.75E+01**	3.02E+00	3.35E-01	1.7E-05	3.4E+00	--	--	--	--
Cadmium	2.05E-01	**1.00E-01**	8.06E-03	3.80E-04	2.0E-08	8.4E-03	4.43E-02	0.2	1.94E+00	0.004
Chromium	1.32E+01	1.39E+00	1.12E-01	2.45E-02	1.3E-06	1.4E-01	--	--	--	--
Cobalt	8.58E+00	2.50E-01	2.01E-02	1.59E-02	8.2E-07	3.6E-02	1.52E+00	0.02	2.33E+01	0.002
Copper	1.82E+01	2.02E+00	1.63E-01	3.36E-02	1.7E-06	2.0E-01	1.94E+00	0.1	4.37E+02	0.0004
Lead	1.19E+01	3.47E-01	5.59E-03	4.41E-03	1.1E-06	1.0E-02	1.77E-03	6	1.55E+02	0.0001

TABLE 7-13

DOSE AND HAZARD QUOTIENT CALCULATIONS USING BTAG TRVs
SITE FTIR-40 AREA 1 AND REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

COPEC	Exposure Point Concentration (EPC) EPC_{Soil} [a] (mg/kg)	EPC_{Plant} [b] (mg/kg)	Food Ingestion $Dose_{food}$ [c] (mg/kg-day)	Incidental Soil Ingestion $Dose_{soil}$ [d] (mg/kg-day)	Dermal Exposure $Dose_{dermal}$ [e] (mg/kg-day)	Total Exposure $Dose_{total}$ [f] (mg/kg-day)	BTAG TRV_{Low} [g] (mg/kg-day)	HQ [h] (unitless)	BTAG TRV_{High} [i] (mg/kg-day)	HQ (unitless)
Site FTIR-40 Reference Area 2 (cont'd)										
Manganese	3.88E+02	2.07E+01	1.67E+00	7.19E-01	3.7E-05	2.4E+00	1.03E+01	0.2	1.15E+02	0.02
Nickel	1.32E+01	3.09E-01	2.49E-02	2.44E-02	1.3E-06	4.9E-02	1.64E-01	0.3	3.89E+01	0.001
Selenium	1.08E+00	3.44E-01	2.77E-02	2.01E-03	1.0E-07	3.0E-02	6.14E-02	0.5	8.36E-01	0.04
Silver	1.04E+00	2.50E-01	2.01E-02	1.93E-03	9.9E-08	2.2E-02	--	--	--	--
Zinc	5.35E+01	3.64E+00	2.93E-01	9.90E-02	5.1E-06	3.9E-01	6.69E+00	0.06	4.64E+02	0.007
							Hazard Index:	7	Hazard Index:	0.08

Notes:

[a] 95% UCL or maximum concentration in surface soil (0 - 1 foot bgs). Maximum concentrations in **bold** (See Table 7-3).

[b] Dietary exposure point concentration is the 95% UCL or maximum of measured concentration in dietary items (plants). Maximum values in **bold** (See Table 7-4).

[c] $Dose_{food} = EPC_{soil} \times IR_{plant}$

where: IR_{plant} - Injestion rate of plants from Table 7-7.

[d] $Dose_{soil} = EPC_{soil} \times IR_{soil} \times ED \times SUF$

where: IR_{soil} - Injestion rate of soil from Table 7-7.

ED - Exposure Duration from Table 7-7.

SUF - Site Utilization Factor from Table 7-7.

[e] $Dose_{dermal} = (EPC_{soil} \times SSA \times AF \times ABS \times ED \times SUF)/BW$

where: SSA - Skin Surface Area from Table 7-7.

AF - soil adherance factor from Table 7-7.

ABS - the dermal absorption factor from Table 7-7.

SUF - Site Utilization Factor from Table 7-7.

BW - Mojave Ground Squirrel's Body Weight from Table 7-7.

[f] $Dose_{total} = Dose_{food} + Dose_{soil} + Dose_{dermal}$

[g] BTAG TRV_{low} and BTAG TRV_{high} were presented in Table 7-9a and 7-7b.

[h] $HQ = Dose_{total}/TRV_{Army}$

[i] The hazard index is defined as the sum of the individual hazard quotients.

COPEC - Chemical of potential ecological concern
EPC - Exposure Point Concentration
HQ -Hazard Quotient
TRV - Toxicity Reference Value

TABLE 7-14

DOSE AND HAZARD QUOTIENT CALCULATIONS USING ARMY TRVs
SITE FTIR-40 AREA 2 AND REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 1 of 2)

COPEC	Exposure Point Concentration (EPC) EPC_{Soil} [a] (mg/kg)	EPC_{Plant} [b] (mg/kg)	Food Ingestion $Dose_{food}$ [c] (mg/kg-day)	Incidental Soil Ingestion $Dose_{soil}$ [d] (mg/kg-day)	Dermal Exposure $Dose_{dermal}$ [e] (mg/kg-day)	Total Exposure $Dose_{total}$ [f] (mg/kg-day)	Army TRV_{Army} [g] (mg/kg-day)	HQ [h] (unitless)
Site 40 Area 2								
Arsenic	9.79E+00	1.52E-01	1.23E-02	1.81E-02	9.3E-07	3.0E-02	9.1E-02	0.3
Cadmium	3.50E-01	1.49E-01	1.20E-02	6.48E-04	3.3E-08	1.3E-02	2.5E-01	0.05
Lead	8.24E+01	4.59E-01	7.40E-03	3.05E-02	7.9E-06	3.8E-02	1.5E+00	0.03
Zinc	1.01E+02	1.79E+01	1.45E+00	1.88E-01	9.7E-06	1.6E+00	2.1E+02	0.01
							Hazard Index:	0.4
Site 40 Reference Area (Reference Area 2)								
Arsenic	8.12E+00	1.50E-01	1.21E-02	1.50E-02	7.7E-07	2.7E-02	9.1E-02	0.3
Cadmium	2.05E-01	1.00E-01	8.06E-03	3.80E-04	2.0E-08	8.4E-03	2.5E-01	0.03
Lead	1.19E+01	3.47E-01	5.59E-03	4.41E-03	1.1E-06	1.0E-02	1.5E+00	0.007
Zinc	5.35E+01	3.64E+00	2.93E-01	9.90E-02	5.1E-06	3.9E-01	2.1E+02	0.002
							Hazard Index:	0.3

Notes:

[a] 95% UCL or maximum concentration in surface soil (0 - 1 foot bgs). Maximum concentrations in **bold** (See Table 7-5).

[b] Dietary exposure point concentration is the 95% UCL or maximum of measured concentration in dietary items (plants). Maximum values in **bold** (See Table 7-6).

[c] $Dose_{food} = EPC_{soil} \times IR_{plant}$

where: IR_{plant} - Injestion rate of plants from Table 7-7.

TABLE 7-14

DOSE AND HAZARD QUOTIENT CALCULATIONS USING ARMY TRVs
SITE FTIR-40 AREA 2 AND REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 2 of 2)

	Exposure Point Concentration (EPC)		Food Ingestion	Incidental Soil Ingestion	Dermal Exposure	Total Exposure	Army	
COPEC	EPC_{Soil} [a] (mg/kg)	EPC_{Plant} [b] (mg/kg)	$Dose_{food}$ [c] (mg/kg-day)	$Dose_{soil}$ [d] (mg/kg-day)	$Dose_{dermal}$ [e] (mg/kg-day)	$Dose_{total}$ [f] (mg/kg-day)	TRV_{Army} [g] (mg/kg-day)	HQ [h] (unitless)

[d] $Dose_{soil} = EPC_{soil} \times IR_{soil} \times ED \times SUF$
where: IR_{soil} - Ingestion rate of soil from Table 7-7.
ED - Exposure Duration from Table 7-7.
SUF - Site Utilization Factor from Table 7-7.
[e] $Dose_{dermal} = (EPC_{soil} \times SSA \times AF \times ABS \times ED \times SUF)/BW$
where: SSA - Skin Surface Area from Table 7-7.
AF - soil adherance factor from Table 7-7.
ABS - the dermal absorption factor from Table 7-7.
SUF - Site Utilization Factor from Table 7-7.
BW - Mojave Ground Squirrel's Body Weight from Table 7-7.
[f] $Dose_{total} = Dose_{food} + Dose_{soil} + Dose_{dermal}$
[g] Army Toxicity Reference Values (TRV_{Army}) were presented in Table 7-8.
[h] $HQ = Dose_{total}/TRV_{Army}$
[i] The hazard index is defined as the sum of the individual hazard quotients.

COPEC - Chemical of potential ecological concern
EPC - Exposure Point Concentration
HQ -Hazard Quotient
TRV - Toxicity Reference Value

TABLE 7-15

DOSE AND HAZARD QUOTIENT CALCULATIONS USING BTAG TRVs
SITE FTIR-40 AREA 2 AND REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

COPEC	Exposure Point Concentration (EPC) EPC$_{Soil}$ [a] (mg/kg)	EPC$_{Plant}$ [b] (mg/kg)	Food Ingestion Dose$_{food}$ [c] (mg/kg-day)	Incidental Soil Ingestion Dose$_{soil}$ [d] (mg/kg-day)	Dermal Exposure Dose$_{dermal}$ [e] (mg/kg-day)	Total Exposure Dose$_{total}$ [f] (mg/kg-day)	BTAG TRV$_{Low}$ [g] (mg/kg-day)	HQ [h] (unitless)	BTAG TRV$_{High}$ [i] (mg/kg-day)	HQ (unitless)
Site FTIR-40 Area 2										
Arsenic	9.79E+00	1.52E-01	1.23E-02	1.81E-02	9.3E-07	3.0E-02	4.24E-01	0.07	4.72E+00	0.01
Cadmium	3.50E-01	1.49E-01	1.20E-02	6.48E-04	3.3E-08	1.3E-02	4.43E-02	0.3	1.94E+00	0.01
Lead	8.24E+01	4.59E-01	7.40E-03	3.05E-02	7.9E-06	3.8E-02	1.77E-03	21	1.55E+02	0.0002
Zinc	1.01E+02	1.79E+01	1.45E+00	1.88E-01	9.7E-06	1.6E+00	6.69E+00	0.2	4.64E+02	0.004
							Hazard Index:	22	Hazard Index:	0.02
Site FTIR-40 Reference Area 2										
Arsenic	8.12E+00	1.50E-01	1.21E-02	1.50E-02	7.7E-07	2.7E-02	4.24E-01	0.06	4.72E+00	0.01
Cadmium	2.05E-01	**1.00E-01**	8.06E-03	3.80E-04	2.0E-08	8.4E-03	4.43E-02	0.2	1.94E+00	0.004
Lead	1.19E+01	3.47E-01	5.59E-03	4.41E-03	1.1E-06	1.0E-02	1.77E-03	6	1.55E+02	0.0001
Zinc	5.35E+01	3.64E+00	2.93E-01	9.90E-02	5.1E-06	3.9E-01	6.69E+00	0.06	4.64E+02	0.001
							Hazard Index:	6	Hazard Index:	0.01

Notes:

[a] 95% UCL or maximum concentration in surface soil (0 - 1 foot bgs). Maximum concentrations in **bold** (See Table 7-5).
[b] Dietary exposure point concentration is the 95% UCL or maximum of measured concentration in dietary items (plants). Maximum values in **bold** (See Table 7-6).

[c] $Dose_{food} = EPC_{soil} \times IR_{plant}$
where: IR_{plant} - Injestion rate of plants from Table 7-7.

TABLE 7-15

DOSE AND HAZARD QUOTIENT CALCULATIONS USING BTAG TRVs
SITE FTIR-40 AREA 2 AND REFERENCE AREA (RF2)
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 2 of 2)

COPEC	Exposure Point Concentration (EPC) EPC_{Soil} [a] (mg/kg)	EPC_{Plant} [b] (mg/kg)	Food Ingestion $Dose_{food}$ [c] (mg/kg-day)	Incidental Soil Ingestion $Dose_{soil}$ [d] (mg/kg-day)	Dermal Exposure $Dose_{dermal}$ [e] (mg/kg-day)	Total Exposure $Dose_{total}$ [f] (mg/kg-day)	BTAG TRV_{Low} [g] (mg/kg-day)	HQ [h] (unitless)	BTAG TRV_{High} [i] (mg/kg-day)	HQ (unitless)

[d] $Dose_{soil} = EPC_{soil} \times IR_{soil} \times ED \times SUF$
where: IR_{soil} - Injestion rate of soil from Table 7-7.
ED - Exposure Duration from Table 7-7.
SUF - Site Utilization Factor from Table 7-7.
[e] $Dose_{dermal} = (EPC_{soil} \times SSA \times AF \times ABS \times ED \times SUF)/BW$
where: SSA - Skin Surface Area from Table 7-7.
AF - soil adherance factor from Table 7-7.
ABS - the dermal absorption factor from Table 7-7.
SUF - Site Utilization Factor from Table 7-7.
BW - Mojave Ground Squirrel's Body Weight from Table 7-7.
[f] $Dose_{total} = Dose_{food} + Dose_{soil} + Dose_{dermal}$
[g] BTAG TRV_{low} and BTAG TRV_{high} were presented in Table 7-9a and 7-7b.
[h] $HQ = Dose_{total}/TRV_{Armv}$
[i] The hazard index is defined as the sum of the individual hazard quotients.

COPEC - Chemical of potential ecological concern
EPC - Exposure Point Concentration
HQ -Hazard Quotient
TRV - Toxicity Reference Value

TABLE 7-16

RESULTS OF STATISTICAL COMPARISONS BETWEEN SITE AND REFERENCE AREA SOIL CONCENTRATIONS[a]
SITES FTIR-38 AREA 2, FTIR-40 AREA 1.1 AND FTIR-40 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

Site	Associated Reference Area	COPEC	Data Fits Normal distribution?	Data fits log-normal distribution?	Reference Data Also normal and/ or log-normal?	Comparison Test	Site Soil Concentrations Statistically Greater Than Reference Concentrations?
38-2	REF-1	Aluminum	No	Yes	Yes	Logarithmic Student -T	Yes
	REF-1	Antimony	No	No	NA	Mann Whitney	No
	REF-1	Lead	No	Yes	Yes	Logarithmic Student -T	Yes
40-1	REF-2	Aluminum	No	No	NA	Mann Whitney	No
	REF-2	Antimony	No	No	NA	Mann Whitney	No
	REF-2	Cadmium	No	No	NA	Mann Whitney	Yes
	REF-2	Copper	No	No	NA	Mann Whitney	Yes
	REF-2	Lead	No	No	NA	Mann Whitney	No[b]
	REF-2	Zinc	No	No	NA	Mann Whitney	Yes
40-2	REF-2	Lead	No	No	NA	Mann Whitney	No

Notes:

[a] See Appendix H for a more thorough presentation of the statistical evaluation.

[b] Statististical comparisons between reference and site data show no difference in the means. However, the large variation in the data would indicate that this may be a false conclusion (Type II error) and these statistics were rejected for COEC identification purposes (See Table 7-18).

COPEC - Chemical of Potential Ecological Concern
COEC - Chemical of Ecological Concern
NA - Not Applicable
REF-1 - Reference Area 1
REF-2 - Reference Area 2

TABLE 7-17

RESULTS OF STATISTICAL COMPARISONS BETWEEN SITE AND REFERENCE AREA PLANT CONCENTRATIONS
SITES FTIR-38 AREA 2, FTIR-40 AREA 1.1 AND FTIR-40 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

Site	Associated Reference Area	COPEC	Data Fits Normal distribution?	Data fits log-normal distribution?	Reference Data Also normal and/ or log-normal?	Comparison Test	Site Plant Concentrations Statistically Greater Than Reference Concentrations?
38-2	REF-1	Aluminum	Yes	NA	Yes	Student T-test	No
	REF-1	Antimony	Yes	NA	Yes	Poisson	No
	REF-1	Lead	Yes	NA	Yes	Student T-test	No
40-1	REF-2	Aluminum	Yes	NA	Yes	Student T-test	No
	REF-2	Antimony	No	No		Poisson	No
	REF-2	Cadmium	No	No	Yes	Mann-Whitney	No
	REF-2	Copper	Yes	NA	Yes	Student T-test	Yes
	REF-2	Lead	Yes	NA	Yes	Student T-test	No
	REF-2	Zinc	Yes	NA	Yes	Student T-test	No
40-2	REF-2	Lead	Yes	NA	Yes	Student T-test	No

Notes:

[a] See Appendix H for a more thorough presentation of the statistical evaluation.

COPEC - Chemical of Potential Ecological Concern
COEC - Chemical of Ecological Concern
NA - Not Applicable
REF-1 - Reference Area 1
REF-2 - Reference Area 2

TABLE 7-18

SUMMARY OF ECOLOGICAL RISK RESULTS BASED ON ARMY AND BTAG TRVs
SITES FTIR-38 AREA 2, FTIR-40 AREA 1.1, AND FTIR-40 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

	Army TRV			Site Concentrations Statistically Greater Than Reference Concentrations?		BTAG TRV_{Low}			Site Concentrations Statistically Greater Than Reference Concentrations?		BTAG TRV_{High}			
Site	HI	Risk Driver	HQ	Soil	Plant	HI	Risk Driver	HQ	Soil	Plant	HI	Risk Driver	HQ	COEC?[a]
38-2	40	Aluminum	36	Yes	No	795	--		--	--	<1.0	--		Yes(a)
		Antimony	2	No	No		--		--	--		--		No
		--		--	--		Lead	794	Yes	No		--		Yes(b)
40-1	43	Aluminum	28	No	No	8074	--		--	--	<1.0	--		No
		Antimony	3	No	No		--		--	--		--		No
		--		--	--		Cadmium	3	Yes	No		--		Yes(b)
		Copper	1	Yes	Yes		Copper	12	Yes	Yes		--		Yes(a), Yes(b)
		Lead	9	No[b]	No		Lead	8055	No[b]	No		--		Yes(a), Yes(b)
		--		--	--		Zinc	3	Yes	No		--		Yes(b)
40-2	<1.0	--		--	--	22	Lead	22	No	No	<1.0	--		No
REF 1	34	Aluminum	31	--	--	7	--		--	--	<1.0	--		--
		Antimony	2	--	--		--		--	--		--		--
		--		--	--		Lead	6	--	--		--		--
REF-2	24	Aluminum	20	--	--	7	--		--	--		--		--
		Antimony	2	--	--		--		--	--		--		--
		--		--	--		Cadmium	0.2	--	--		--		--
		Copper	0.01	--	--		Copper	0.1	--	--		--		--
		Lead	0.007	--	--		Lead	6	--	--		--		--
		--		--	--		Zinc	0.06	--	--		--		--

Notes:

[a] Yes(a) -- HQ based on TRV_{Army} is >1.0 and site concentrations statistically greater than reference concentrations.

Yes(b) -- HQ based on TRV_{BTAG} is >1.0 and site concentrations statistically greater than reference concentrations.

No -- Although HQ based on TRV_{Army} or TRV_{BTAG} is greater than one, site concentrations are statistically less than reference concentrations.

[b] Statistical comparisons between reference and site data show no difference in the means. However, the large variation in the data would indicate that this may be a false conclusion (Type II error) and these statistics were rejected for COEC identification purposes.

TABLE 7-19

SUMMARY OF CHEMICALS OF ECOLOGICAL CONCERN (COECs)
SITES FTIR-38 AREA 2, FTIR-40 AREA 1.1, AND FTIR-40 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

Site	Chemical
Site FTIR-38 Area 2	Aluminum Lead
Site FTIR-40 Area 1.1	Cadmium Copper Lead Zinc
Site FTIR-40 Area 2	none

TABLE 8-1

POTENTIAL CHEMICAL-SPECIFIC ARARS AND TBCS
NATIONAL TRAINING CENTER, FORT IRWIN

Source or Authority	Requirement, Standard, or Criterion	Type	Description	Remarks
			Federal ARARs and TBCs	
USEPA	Region 9 Preliminary Remediation Goals	TBC	Considered screening – level remediation goals. Not site-specific. Citations for residential scenario only. Aluminum – 76,000 mg/kg (residential only) Cadmium – 37 mg/kg (residential only) Copper – 2,900 mg/kg (residential only) Lead – 400 mg/kg (residential only) Zinc – 23,000 mg/kg (residential only)	
USEPA	Generic Soil Screening Levels for Superfund	TBC	Considered screening-level, not for remediation, specific pathways considered. Not site-specific. Citation for residential scenario only. Aluminum – not available Cadmium - 39 mg/kg (ingestion) - 920 mg/kg (inhalation) Copper – not available Lead - 400 mg/kg (ingestion) - inhalation – not available data Zinc – 23,000 mg/kg (ingestion) - inhalation – not available data	

TABLE 8-1

POTENTIAL CHEMICAL-SPECIFIC ARARS AND TBCS
NATIONAL TRAINING CENTER, FORT IRWIN

Source or Authority	Requirement, Standard, or Criterion	Type	Description	Remarks
DTSC	SF Bay Area Guidance for Naval Facilities	TBC	Clean-up goals based on BTAG TRVs. BTAG prepared the following TRV_{Low} and TRV_{high} values: Aluminum – not calculated Cadmium – 0.044 mg/kg-day and 1.94 mg/kg-day Copper – 1.9 mg/kg-day and 437 mg/kg-day Lead – 0.0018 mg/kg-day and 155 mg/kg-day Zinc – 6.7 mg/kg-day and 464 mg/kg-day	These daily doses represent a range of possible effect scenarios (no effects to median sub-lethal effects). They were used to help identify potential ecological stressors.
USACE	Phase II Validation Study/Ecological Risk Assessment (Section 7.0)	TBC	Clean-up goals based on Army TRVs: Aluminum – 1.4 mg/kg-day Cadmium – 0.25 mg/kg-day Copper – 20 mg/kg-day Lead – 1.5 mg/kg-day Zinc – 210 mg/kg-day	These daily doses were used to define a minimal ecologically significant effect.
USACE	HHRA (Section 6)	TBC	Clean-up goals based on human exposure scenarios.	
USACE	BUTLs for constituents in soils	TBC	BUTLs calculated by Parsons (1996), cited in Section 4.0, Table 4-1: Aluminum – 23,600 mg/kg Cadmium – 0.416 mg/kg Copper – 28.7 mg/kg Lead – 7.33 mg/kg Zinc – 51 mg/kg	These values are considered reasonable estimates of ambient chemical conditions of metals in soil.

ARAR – Applicable or Relevant and Appropriate Requirement
BTAG – Biological Toxicological Advisory Group
BUTL – Background Upper Tolerance Limit
HHRA – Human Health Risk Assessment

mg/kg – milligrams per kilogram
mg/kd-day – milligrams per kilogram per day
TBC – To Be Considered
TRV – toxicity reference value

TABLE 8-2

POTENTIAL ACTION-SPECIFIC ARARS AND TBCS
NATIONAL TRAINING CENTER, FOR IRWIN

Source or Authority	Requirement, Standard, or Criterion	Potential Type	Description
			Federal ARARs
Federal Clean Water Act	40 CFR 122, 123, and 124 USEPA Administered Permit Programs: The NPDES	See Subsection(s) Listed Below	Requirements to ensure storm water discharges from remedial action activities do not contribute to a violation of surface water quality standards.
			All reasonable steps must be taken to minimize or prevent discharges which have a reasonable likelihood of causing adverse impacts on surface water quality (40 CFR 122.41(d)). Discharges into surface water must achieve federal and state water quality standards (40 CFR 122.44(d)).
		Applicable	If construction involves five or more acres.
		Relevant & Appropriate	If construction is less than five acres
Clean Air Act	40 CFR 50 NAAQS	Applicable	Section 109 of the CAA defines the NAAQS that are listed in 40 CFR 50. The NAAQS establish emission limits for specific compounds. These standards may be applicable if onsite actions (such as soil excavation and other construction) generate particulates.
Resource Conservation and Recovery Act	40 CFR Parts 261, 262, 264 and 268 as follows.		California is authorized to administer the RCRA program through the state regulations located in Title 22 of the CCR, Division 4.5. 40 CFR Part 261 requirements are incorporated into Chapter 11; 40 CFR Part 262 requirements are incorporated into Chapter 12; 40 CFR Part 264 requirements are incorporated into Chapter 14; and 40 CFR Part 268 requirements are incorporated into Chapter 18.
	Part 261 (Identification and Listing of Hazardous Waste)	Applicable	Defines solid wastes that are subject to regulation as listed wastes and characteristics which can require a solid waste to be regulated as hazardous (even if it is not a listed waste).
	Part 262 (Standards Applicable to Generators as Hazardous Waste)	Applicable	Establishes requirements for generators of hazardous waste including waste classification, packaging, labeling, accumulation time, and transport.

TABLE 8-2

**POTENTIAL ACTION-SPECIFIC ARARS AND TBCS
NATIONAL TRAINING CENTER, FOR IRWIN**

Source or Authority	Requirement, Standard, or Criterion	Potential Type	Description
Resource Conservation and Recovery Act (cont'd)	Part 264 (Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities)	Applicable	This part specifies requirements for storage or treatment of hazardous wastes in drums/containers and tanks; and storage/treatment or disposal of hazardous wastes in land based management units such waste piles and landfills. The substantive requirements of this part are applicable to treatment in tanks or containers (per the generator standards), although permits are not required if treatment is performed in less than 90 days. This part also sets forth the requirements to designate and manage CAMU for the onsite management of media (i.e., soil, sediment, groundwater, etc.) containing hazardous waste that would otherwise be subject to RCRA LDRs. These regulations would be applicable if a CAMU designation is obtained for any of the Ft. Irwin sites. The CAMU would potentially allow for the placement of wastes exceeding their respective LDRs. The CAMU would have to meet siting and construction standards for hazardous waste units (i.e., see 23 CCR, Division 3, Chapter 15 description under State of California Hazardous Waste ARARs section of this table and Table 3-7 (location-specific ARARs).
	Part 268 (Land Disposal Restrictions)	Applicable	This part identifies the wastes subject to LDRs and specifies the treatment standards that must be complied with prior to land disposal.
			Federal TBC
TBC	Contained-In Policy	Applicable	The Contained-In Policy is a TBC which applies to decisions regarding the classification of environmental media as hazardous wastes. The Contained-In Policy was first articulated in a November 13, 1986 memorandum, "RCRA Regulatory Status of Contaminated Groundwater". It has been updated multiple times in Federal Register preambles, EPA memos and guidance (e.g., 53 FR 31138, 31142, 31148 (Aug. 17, 1988); 57 FR 21450, 21453 (May 20, 1992); a detailed discussion in HWIR-Media proposal preamble, 61 FR 18795 (April 29, 1996), and a description in Management of Remediation Waste Under RCRA (EPA, October 1998; EPA530-F-98-026). Contaminated environmental media, of itself, is not a RCRA-regulated hazardous waste. Contaminated environmental media becomes regulated under RCRA only if it "contains" hazardous waste. EPA generally considers contaminated environmental media to contain hazardous waste when: (1) it exhibits a hazardous waste characteristic (corrosivity, ignitability, reactivity or toxicity); or (2) it is contaminated with concentrations of constituents from a listed waste (F, K, U or P codes) that are above health-based limits. Environmental media containing hazardous waste are subject to RCRA until they no longer contain the hazardous waste. The approval of EPA or authorized state is required for a "contained-in determination" when the media was impacted with a listed waste to manage it as nonhazardous.

TABLE 8-2

POTENTIAL ACTION-SPECIFIC ARARS AND TBCS
NATIONAL TRAINING CENTER, FOR IRWIN

Source or Authority	Requirement, Standard, or Criterion	Potential Type	Description
			State of California Hazardous Waste ARARs
California Hazardous Waste Control Law	22 CCR, Division 4.5 Chapter 11 Identification and Listing of Hazardous Waste	Applicable	Identifies whether the wastes are RCRA or non-RCRA hazardous or non-hazardous. Management of wastes classified as hazardous must comply with other pertinent sections of Title 22 as described in the following references.
	22 CCR, Division 4.5 Chapter 12 (Standards Applicable to Generators of hazardous waste) 22 CCR 66262.10-66262.-89	Applicable	These standards are only applicable to those sites where excavated wastes are classified as hazardous waste. These standards establish requirements for generators of hazardous waste located in California. The standards are applicable to onsite storage of hazardous waste and offsite waste management. These standards would also be applicable if onsite treatment of wastes classified as hazardous is conducted. In this event, wastes would have to be treated in tanks or containers in less than 90 days – in compliance with generator standards.
	CCR Division 4.5, Chapter 14 (Standards for Owners and Operators of Hazardous Waste Transfer, Treatment, Storage, and Disposal Facilities)	See Subsection(s) Listed Below	

TABLE 8-2

**POTENTIAL ACTION-SPECIFIC ARARS AND TBCS
NATIONAL TRAINING CENTER, FOR IRWIN**

Source or Authority	Requirement, Standard, or Criterion	Potential Type	Description
California Hazardous Waste Control Law (cont'd)	Article 9 (Use and Management of Containers) 22 CCR 66264.170 through 22 CCR 66264.179	Applicable	The chemicals recovered from surface soils or subsurface soils may need to be managed as either a RCRA or non-RCRA hazardous waste. The Article 9 requirements are applicable if the waste material is classified as hazardous and the waste is placed in containers. The requirements include using containers to store the recovered product that are compatible with this material (22 CCR 66264.172); using containers that are in good condition (22 CCR 66264.171); segregating the waste from incompatible wastes (22 CCR 66264.177); inspecting the containers (22 CCR 66264.176); and providing adequate secondary containment for the water stored (22 CCR 66264.175); containers must be closed during transfer (22 CCR 66264.173); and all hazardous material must be removed at closure (22 CCR 66264.178). If during excavation or cleanup activities hazardous waste is identified throughout the waste characterization process, the hazardous waste will be managed in accordance with the requirements of the standards. This option may be used for waste storage prior to offsite shipment. This option may also be used for onsite treatment as treatment in tanks or containers in less than 90 days does not require a RCRA permit.
	Article 1 (General) 22 CCR 66268.1 through 22 CCR 66268.9	Applicable	Provides the purpose, scope, and applicability of LDRs. The title of the sections of the regulations are; 22 CCR 66268.3 - Dilution Prohibited As a Substitute for Treatment; 22 CCR 66268.7 - Waste Analysis and Record keeping; and 22 CCR 66268.9 - Special Rules Regarding Wastes That Exhibit a Characteristic. If during excavation or cleanup activities hazardous waste is identified through the proper characterization process and will be land disposed within the meaning of the LDRs, the hazardous waste will be managed in accordance with the standards stated in applicable sections of the regulation. Only applicable if hazardous wastes are disposed of or treated in an area not designated as a CAMU or disposed of or treated beyond the area of contamination.
	Article 3 (Prohibitions on Land Disposal) 22 CCR 66268.30 through 22 CCR 66268.35	Applicable	These standards are applicable to sites where excavated material is classified as hazardous waste and is disposed of or treated in an area not designated as a CAMU. Provides waste-specific LDRs for 22 CCR 66268.30 - Waste Specific Prohibitions--Solvent Wastes; 22 CCR 66268.31 - Waste Specific Prohibitions--Dioxin-Containing Wastes; 22 CCR 66268.32 - Waste Specific Prohibitions--California List Wastes; 22 CCR 66268.33 - Waste Specific Prohibitions--First Third Wastes; 22 CCR 66268.34 - Waste Specific Prohibitions--Second Third Waste; and 22 CCR 66268.35 - Waste Specific Prohibitions--Third Waste. If during excavation, treatment processes, or cleanup activities hazardous waste is identified through the proper characterization process and will be land disposed within the meaning of the LDRs, the hazardous waste will be managed in accordance with the standards stated in these sections of the regulation.

TABLE 8-2

POTENTIAL ACTION-SPECIFIC ARARS AND TBCS NATIONAL TRAINING CENTER, FOR IRWIN

Source or Authority	Requirement, Standard, or Criterion	Potential Type	Description
California Hazardous Waste Control Law (cont'd)	Article 5 (Prohibitions on Storage) 22 CCR 66268.50	Relevant & Appropriate	This standard is applicable to sites where excavated material is classified as hazardous waste. The standard provides prohibitions on storage of restricted wastes. If during excavation, treatment processes, or cleanup activities hazardous waste is identified through the proper characterization process, and will be land disposed within the meaning of the LDRs, the hazardous waste will be managed in accordance with the standards stated in these sections of the regulation.
			State of California Air ARARs
California Clean Air Act	Mojave Desert AQMD Rule 403.2 Fugitive Dust:	Applicable	This regulation requires dust emissions not to exceed PM10. Sources include Reduce Trackout to pave surfaces. Cover loaded haul vehicles. Reduce activity under high wind conditions. 100 or more acres shall comply with provisions of subsection (3) of 403.2, that requires a dust control plan, using paved haul routes whenever possible.
	Mojave Desert AQMD	Applicable	Permit requirements
			State of California Groundwater and Soil ARARs
California Water Code	State Water Resources Control Board Order 92-08-DWQ (General order for storm water management at construction sites)	Applicable	Applies to construction sites five acres or greater in size. It also applies to smaller sites that are part of a larger common plan of development or sale. Must identify the sources of sediment and other pollutants that affect the quality of storm water discharges and implement practices to reduce these discharges. Storm water discharges from construction sites must meet pollutant limits and standards. The narrative effluent standard includes the requirements to implement best management practices and/or appropriate pollution prevention control practices. Inspections of the construction site prior to anticipated storm events and after actual storm events need to be conducted to identify areas contributing to storm water discharge and evaluated for the effectiveness of BMPs and other control practices. Note: may be relevant and appropriate to construction involving 5 acres or more.

TABLE 8-2

POTENTIAL ACTION-SPECIFIC ARARS AND TBCS
NATIONAL TRAINING CENTER, FOR IRWIN

Source or Authority	Requirement, Standard, or Criterion	Potential Type	Description
Porter-Cologne Water Quality Control Act (California Water Code Sections 13140-13147, 13172, 13260, 13263, 13267, 13304)	Title 23 (Waters), Division 3 (State Water Resources Control Board), Chapter 15 (Discharges of Hazardous Waste to Land), Article 2 (Waste Classification and Management)	Applicable	Waste Classification and Management: Wastes must be classified and managed as either hazardous waste, designated waste, nonhazardous solid waste, or inert waste. A hazardous waste can only be discharged to a Class I facility (unless a variance is applicable under Title 22 regulations). A designated waste can be discharged to a Class I or Class II facility. A nonhazardous solid waste can be discharged to a Class I, II, or III facility. Inert wastes do not need to be sent to a classified facility.
Porter-Cologne Water Quality Control Act (California Water Code Sections 13140-13147, 13172, 13260, 13263, 13267, 13304) (cont'd)	Title 27 (Environmental Protection) Division 2 (Solid Waste), Chapter 3 (Criteria for all waste management units, facilities, and disposal sites)		Division 2 of Title 27 establishes criteria for classification and management of wastes in land based units (waste piles, surface impoundments, and landfills). Wastes classified as hazardous wastes must be managed in Class I units in accordance with Title 22, Division 4.5. This title regulates Class II and Class III units for designated and nonhazardous wastes.
	Article 2 (SWRCB - Waste Classification and Management)	Applicable	Wastes must be classified as either: designated waste (27 CCR 20210), nonhazardous solid waste (27 CCR 20220) or inert waste (27 CCR 20230). Designated wastes can only be placed in Class I (Title 23, Div 3, Ch 15) or Class II land units. Nonhazardous solid waste can be placed in Class III units. Inert wastes do not need to be placed in classified units.

AQMD – Air Quality Management District
ARAR - applicable or relevant and appropriate requirements
BMP – Best Management Practices
CAA – Clear Air Act
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
CAMU - Corrective Action Management Unit
CCR - California Code of Regulations
CFR - Code of Federal Regulations
COC - chemical of concern
EPA - Environmental Protection Agency
LDR - land disposal restriction
MCL - Maximum Contaminant Level
NAAQS – National Primary and Secondary Ambient Air Quality Standards
NPDES - National Pollutant Discharge Elimination System
RCRA - Resource Conservation and Recovery Act
RWQCB – Regional Water Quality Control Board
SWRCB - State Water Resources Control Board
TBC – To Be Considered
USACE - United States Army Corps of Engineers
USC- United States Code
USEPA - United States Environmental Protection Agency

TABLE 8-3

POTENTIAL LOCATION-SPECIFIC ARARS
NATIONAL TRAINING CENTER, FORT IRWIN

Source or Authority	Requirement, Standard, or Criterion	Potential Type	Description	Remarks	Associated Sites
			Federal ARARs and TBCs		
ESA 16 U. S. Code (U.S.C.) 1531 *et seq.*		Applicable	Protects federally proposed and listed threatened or endangered animal and plant species and their habitats. The ESA defines "any species which is in danger of extinction throughout all or a significant portion of its range" as endangered, and any species that is likely to become an endangered species within the foreseeable future" as threatened. Avoidance of species taking as well as habitat destruction is required under the Act. Further, federal agencies are directed to conserve threatened and endangered species and to cooperate with state and local agencies to resolve water issues concerning conservation of species. Sensitivity assessment for biological resources is needed to determine whether critical habitat exists. A consultation and biological opinion from U. S. Fish and Wildlife Service will be needed prior to implementing any remedial action, in accordance with the regulation in 50 CFR 402.01.	Applicable if any endangered or threatened species are identified. Sites FTIR-38 and FTIR-40 provide potential habitat for the desert tortoise, a federally listed endangered species.	All sites with endangered species identified.

TABLE 8-3

POTENTIAL LOCATION-SPECIFIC ARARS
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 2 of 3)

Source or Authority	Requirement, Standard, or Criterion	Potential Type	Description	Remarks	Associated Sites
Solid Waste Disposal Act	40 CFR 258	Relevant and Appropriate	Identifies location restrictions to address both the potential effects that a municipal solid waste landfill may have on the surrounding environment, and the effects that natural and human-made conditions may have on the performance of the landfill unit. Restrictions apply to locations within proximity of airports, 100-year floodplains, wetlands, fault areas, seismic impact zones, and unstable areas; unless demonstrations can be made.	These regulations would be relevant and appropriate to onsite landfills constructed for nonhazardous wastes.	Sites where onsite disposal of nonhazardous waste in landfills would occur.
			California Location-Specific ARARs -		
California Endangered Species Act of 1984 and California Native Plant Protection Act	California Fish & Game Code Chapter 15, Article 15, § 1900 – 1913 and § 2050 - 2098	Applicable	These acts provide protection for plant, fish and wildlife species and their habitats designated by the state as rare, threatened, or endangered. Protects these endangered or threatened species by preventing their taking, importation, exportation or sale. Consultation with the California Department of Fish and Game is required prior to commencing any action to determine if it may affect a state-listed endangered, threatened, or rare species. The Department of Fish and Game provide written findings regarding the impact of disturbances on the viability of an endangered species.	Sites FTIR-38 and FTIR-40 provide potential habitat for the Mojave ground squirrel, a state-listed threatened species, and the desert tortoise, both a state and federally listed endangered species.	Sites identified as having native species.

TABLE 8-3

POTENTIAL LOCATION-SPECIFIC ARARS
NATIONAL TRAINING CENTER, FORT IRWIN

Source or Authority	Requirement, Standard, or Criterion	Potential Type	Description	Remarks	Associated Sites
Porter-Cologne Water Quality Control Act (California Water Code Sections 13000, 13140, 13240)	27 CCR, Division 2, Chapter 3, Article 3 (Waste Management Unit, Facility, or Disposal Site Classification and Siting)	Applicable	Specifies location requirements where waste management units for designated and nonhazardous wastes may be located (i.e., Class II and Class III units). Restricted locations are based on proximity to faults, floodplains, and underlying groundwater, unless specific determinations can be made.	These regulations would be applicable to onsite treatment or disposal in land based units for wastes that are not hazardous (i.e., designated and nonhazardous wastes).	Sites where onsite management of designated or nonhazardous waste in land based units would occur.
	23 CCR, Division 3, Chapter 15, Article 3 (Waste Management Unit, Facility, or Disposal Site Classification and Siting)	Applicable	Specifies location requirements where waste management units for hazardous wastes may be located (i.e., Class I units). Locations must not be within 200 feet of active faults, within 100-year floodplains, or within 5 feet of underlying groundwater, unless specific determinations can be made.	These regulations would be applicable to onsite treatment or disposal of hazardous waste in land based units.	Sites where onsite management of hazardous waste in land based units would occur.
California Desert Protection Act of 1994	78 Stat. 890, 16 U.S.C. 1131 et seq. 90 Stat. 2743, 43 U.S.C. 1701 et seq.	Not Applicable	Designates specific tracks of BLM land in the California Desert Conservation Area as wilderness. Expands or creates Death Valley National Park, Joshua Tree National Park, the Mojave National Preserve, Red Rock Canyon State Park, and Desert Lily Sanctuary. Provides for the transfer of the land's administration to the Park Service, or other government agency, as appropriate.	These lands do not include Ft. Irwin or adjacent properties.	

ARAR – Applicable or Relevant and Appropriate Requirement
BLM – Bureau of Land Management
CCR – California Code of Regulations
CFR – Code of Federal Regulations
ESA – Endangered Species Act

RWQCB – Regional Water Quality Control Board
SWRCB – State Water Resources Control Board
TBC – To be considered
USACE – United States Army Corps of Engineers
USC – United States Code

TABLE 8-4

SITE-SPECIFIC CLEANUP LEVELS
NATIONAL TRAINING CENTER, FORT IRWIN

Site/Medium/Chemical of Concern	Maximum Concentration[a] (mg/kg)	95% UCL Concentration[b] (mg/kg)	Ft Irwin BUTL Concentration[c] (mg/kg)	Human Health Risk-Based Cleanup Level (mg/kg)	Ecological Risk-Based Cleanup Level (mg/kg)	Site-Specific Cleanup Level (mg/kg)
FTIR-38 Area 2						
Surface soils						
Aluminum	41,400	22,051	23,600		605[g]	**23,600**
Lead	6,430	3,753	7.33	3,475[e]	4,000[g]	**3,475**
FTIR-40 Area 1.1						
Surface soils						
Copper	12,900	12,069	28.7		10,900[g]	**10,900**
Lead	38,400	na[f]	7.33	3,475[e]	4,000[g]	**3,475**

Notes:
[a] Maximum concentration detected in the indicated medium.
[b] The 95 percent upper confidence limit on the mean (95% UCL) concentration, as calculated in the Human Health Risk Assessment (HHRA).
[c] The background upper tolerance limit (BUTL) determined for Fort Irwin soils (Parsons, 1996).
[d] Risk-based cleanup level for soils, developed from the Human Health Risk Assessment (HHRA).
[e] Cleanup level is based on the PRG-99 for lead, as derived from DTSC's *Lead Risk Assessment Spreadsheet - Bloodpb7.xls*.
[f] A meaningful 95% UCL concentration could not be calculated from the dataset.
[g] Risk-based cleanup level derived from Phase II Validation Study/Ecological Risk Assessment (ERA)
BUTL - Background upper tolerance limit.
mg/kg - Milligrams per kilogram.
na - Not available.
UCL - Upper confidence limit.

TABLE 9-1

EVALUATION AND SCREENING OF POTENTIALLY APPLICABLE REMEDIAL TECHNOLOGIES FOR SITES FTIR-38 AREA 2 AND FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER, FORT IRWIN

General Response Action	Potentially Applicable Remedial Technology	Effectiveness	Implementability	Cost	Result of Screening	Comments
NO ACTION	5-Year Site Review	Low	Easy	Low	**Retain**	Contaminants will remain on site indefinitely. Includes site walk, evaluation of existing data and current land use.
INSTITUTIONAL CONTROLS	Access & Land Use Restrictions	Low to Moderate	Easy	Low to Moderate	**Retain**	Provides protection to human health (but not ecological receptors) at a relatively low cost.
	Environmental Monitoring:					
	Groundwater	Low	Easy	Low to Moderate	Eliminate	Eliminate based on depth to groundwater and beneficial use of aquifer.
	Storm Water (runoff)	Low	Easy	Low	Eliminate	Not feasible given relatively small annual precipitation rate.
CONTAINMENT	Capping:					
	Asphalt Cap	High	Moderate	Moderate to High	Eliminate	Costly. Disturbs native habitat and requires long-term maintenance and drainage controls.
	Native Soil Cover	Moderate	Moderate	Moderate to High	**Retain**	May provide protection to human health and ecological receptors.
	Clay Cap	Moderate	Difficult	High	Eliminate	Costly and clay has potential to desiccate and crack over time. No protection of burrowing animals.
	Synthetic Liner with Soil Cap	High	Difficult	High	Eliminate	Costly. Low permeability, and readily available; consists of a synthetic liner & native soil cover. Protects human health and ecological receptors; however, requires long-term maintenance.
REMOVAL/DISPOSAL	Excavation and Offsite Disposal	High	Moderate	Moderate to High	**Retain**	Costs and implementability vary greatly with cleanup levels.
	Excavation & Onsite Landfill Disposal	High	Difficult	High	Eliminate	Requires capping or constructing/permitting an onsite Class II or Class I LF. May not protect ecological receptors.
	Screening/Separation	Low	Moderate	Moderate	Eliminate	Causes disturbance of native habitat. Not protective of human health and ecological receptors by itself.
	Surface Debris Removal	Low	Easy	Low to Moderate	**Retain as Support**	Effective when used in conjunction with other technologies. Not protective of human health and ecological receptors by itself. Improves the aesthetics of the site.
TREATMENT	Soil Washing	Moderate	Difficult	High	Eliminate	Eliminate based on costs, implementability, lack of water source and need for offsite water disposal.
	In-Situ Stabilization	Moderate	Moderate	High	Eliminate	Costly and doesn't protect ecological receptors.
	Ex-Situ Stabilization:					
	Stabilizaton/Onsite Disposal	Moderate	Difficult	High	Eliminate	Costly. Requires constructing & permitting an onsite Class II or Class I LF. May not protect ecological receptors.
	Stabilization/Off Site Disposal	High	Difficult	High	Eliminate	Not economically feasible due to volume of soil to be treated. Causes disturbance of native habitat. pretreatment to TCLP standards. May not protect ecological receptors.

Note: Bold entries indicate remedial technologies retained for the development of remedial alternatives.

TABLE 9-2

SUMMARY OF SELECTED GENERAL RESPONSE ACTIONS
SITES FTIR-38 AREA 2 AND FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER, FORT IRWIN

General Response Action	Remedial Technology	
NO ACTION	5-Year Site Review	The 5-year site review would include site visits and evaluation of changes in land use.
INSTITUTIONAL CONTROLS	Access and Land Use Restrictions (1)	Access restrictions would include enforced security. Land use restrictions would involve prohibition of future residential land use, such as housing developments and vehicular traffic.
CONTAINMENT	Engineered Soil Cover	An engineered soil cover would be installed over the site to prevent direct contact with contaminated soil and reduce infiltration.
REMOVAL/DISPOSAL	Excavation and Off-Site Disposal	The contaminated soil would be excavated and diposed off-site at an appropriate landfill. This technology will protect both human health and ecological receptors.
REMOVAL/DISPOSAL	Surface Debris Removal (1,2)	Surface debris would be removed and disposed of appropriately

Note:
(1) Only to be used in conjunction with other remedial technologies
(2) for Site 40 Area 1 1 only

TABLE 10-1

SITE FTIR-38 AREA 2
TCLP AND STLC SAMPLE RESULTS
NATIONAL TRAINING CENTER, FORT IRWIN

Sample ID	XRF Lead Conc. (mg/kg)	TCLP Lead (µg/L)	STLC Lead (µg/L)
38-2-SS-14	1,400	124	21,500
38-2-SS-27	1,700	22,000	768,000

Notes:
µg/L - micrograms per liter
mg/kg - milligrams per kilogram
STLC - soluble threshold leaching concentration
TCLP - toxicity characteristic leaching procedure
XRF - x-ray fluorescence

TABLE 11-1

DETAILED ANALYSIS OF ALTERNATIVES FOR SITE FTIR-38 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

(Page 1 of 3)

Name of Alternative	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Removal/Disposal
Overall Protectiveness			
• Human Health Protection	Cancer risk within 10^{-4} to 10^{-6} for residential and industrial receptors, HQ<1.0.	Limits industrial worker exposure for current and future industrial land use scenarios.	Reduces the potential for direct contact with lead and aluminum impacted soil at concentrations exceeding RAO's.
• Ecological Receptors	Potential impacts to burrowing mammals that uptake/ingest soil. Habitat marginally impacted by metal debris and increased concentration of metals (primarily lead) in soils.	Alternative 2 does not improve habitat compared to No Action (Alternative 1).	Results in a disturbance to ecological receptors. Potential ecological receptors may re-inhabit disturbed areas.
• Soil, Air, Groundwater and Surface Water Protection	Soils impacted by elevated metals concentrations, primarily lead, above background concentrations. Air quality, surface water and groundwater impacts are low and not considered significant.	Soils impacted by elevated metals concentrations, primarily lead, above background concentrations. Air quality, surface water and groundwater impacts are low and not considered significant.	Alternative 3 results in a marginal improvement of long-term soil quality. No significant improvement of air, groundwater or surface water quality beyond Alternatives 1 or 2.
Compliance with ARARs and RAOs	Does not comply with or meet the intent of ARARs. Does not achieve RAOs.	Complies or meets the intent of most ARARs. Does not achieve RAOs.	Meets intent of ARARs. Achieves RAOs.
Long-Term Effectiveness			
• Magnitude of Residual Risk	Does not achieve RAO's. Human health risks from direct contact with impacted soil. Areas with highest concentrations of metals pose marginal risk to ecological receptors. Does not reduce magnitude of residual risk.	Alternative 2 reduces exposure to human, but not ecological receptor exposure. Alternative 2 does not achieve RAO's or reduce long-term residual risk compared to No Action (Alternative 1).	Alternative 3 achieves RAOs, reducing impact to humans and ecological receptors.
• Adequacy and Reliability of Response Actions	Not applicable	Land use restrictions reliable.	Berms left in place, minimal disturbance of existing habitat. Minimal maintenance required.

TABLE 11-1

DETAILED ANALYSIS OF ALTERNATIVES FOR SITE FTIR-38 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

Name of Alternative	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Removal/Disposal
Reduction of Toxicity, Mobility, and Volume (TMV)	None.	None.	Reduces the potential for direct contact with humans and ecological receptors by removing metal (lead and aluminum) impacted soil in order to achieve RAOs.
Short-Term Effectiveness	Not effective, does not achieve RAOs.	Minimal health and safety risks to construction workers during implementation of institutional controls. However, risk involves locating and removing potential UXO.	Physical hazards to construction workers during site work activities. However, hazards are associated with locating and removing potential UXO, working with heavy equipment and around excavations, and airborne lead particulates. Ecological receptors may be disturbed, but will be relocated, if necessary.
Implementability			
• Technical Feasibility	Implementable.	No closure activities undertaken. Signage and deed restrictions easy to implement.	Excavation and offsite disposal for lead and aluminum impacted soil at elevated concentrations above RAOs is moderately easy to implement.
• Availability of Services and Materials	None.	Services for installation of signs are readily available.	Services, equipment and materials for excavation and offsite disposal are readily available.
• Administrative Feasibility	No administrative difficulties associated.	No administrative difficulties associated with implementing deed restrictions, or posting signs.	No administrative difficulties associated with excavation and offsite disposal. Permits and specialized staff required for dust minimization, habitat disturbance. Construction work may be seasonally restricted based on Mojave ground squirrel estivation and reproduction cycles.

TABLE 11-1

DETAILED ANALYSIS OF ALTERNATIVES FOR SITE FTIR-38 AREA 2
NATIONAL TRAINING CENTER, FORT IRWIN

Name of Alternative	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Removal/Disposal
Cost	See Table N-1 for detailed cost estimate of Alternative 1.	See Table N-2 for detailed cost estimate of Alternative 2.	See Table N-3 for detailed cost estimate of Alternative 3.
• Capital Cost	$0	$76,240	$383,810
• Annual O&M Costs	$0	$7,200	$12,000
• Five-Year Site Review	$9,6000	$9,600	$9,600
• Five-Year Present Worth	$7,000	$113,000	$440,000
State Acceptance	Likely to be unacceptable	May be acceptable, although state requires involvement in land use restrictions	Acceptable
Community Acceptance	Likely to be acceptable given the restricted access to the public	Likely to be acceptable given the restricted access to the public	Acceptable, although community may be concerned with disturbance of habitat

TABLE 11-2

DETAILED ANALYSIS OF ALTERNATIVES FOR SITE FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER, FORT IRWIN

Name of Alternative	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Surface Debris Removal With Institutional Controls	Alternative 4 Limited Soil Removal to 3.5 Feet and Backfill with Imported Soil	Alternative 5 Clean Closure
Overall Protectiveness					
• Human Health Protection	Cancer risk within 10^{-4} to 10^{-6} residential and industrial receptors with HQ>1.	Same as Alternative 1, but limits industrial worker exposure for current and future industrial land use scenarios.	Same as Alternative 2, but reduces potential of injury from surface debris; however, does not protect against direct contact with lead impacted soil.	Reduces the potential for direct contact with soil impacted with elevated concentrations of metals (copper and lead).	Reduces the potential for direct contact with soil impacted with elevated concentrations of metals (copper and lead).
• Ecological Receptors	Potential impacts to burrowing animals that uptake/ingest soil. Habitat marginally impacted by metal debris and increased concentration of metals (primarily lead) in soils.	Alternative 2 does not improve habitat compared to No Action (Alternative 1).	Minimal improvement to habitat as compared to Alternatives 1 and 2.	Following site work, ecological receptors may re-inhabit disturbed areas. Soil removal to 3.5 feet will be protective of burrowing ecological receptors.	Following site work, ecological receptors may re-inhabit disturbed areas.
• Soil, Air, Groundwater and Surface Water Protection	Soils impacted by elevated metals concentrations, primarily lead, above background concentrations. Air quality, surface water and groundwater impacts are low and not considered significant.	Soils impacted by elevated metals concentrations, primarily lead, above background concentrations. Air quality, surface water and groundwater impacts are not considered significant.	Minimal disturbance of habitat. Minimal improvement of soil quality: air quality, surface water, and groundwater not impacted.	Alternative 4 results in short-term, disturbance of habitat. Improvement of long-term soil quality, air quality, and groundwater and surface water quality. Groundwater quality not impacted.	Alternative 5 results in a short-term disturbance of habitat. Improvement of long-term soil quality, surface water and air quality. Groundwater not impacted.
Compliance with ARARs and RAOs	Does not comply with ARARs. Does not achieve RAOs.	Complies with the intent of most ARARs. Does not achieve RAOs.	Complies with the intent of most ARARs. Does not achieve RAOs.	Complies with most ARARs. Achieves RAOs.	Complies with most ARARs. Achieves RAOs.

TABLE 11-2

DETAILED ANALYSIS OF ALTERNATIVES FOR SITE FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER, FORT IRWIN

Name of Alternative	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Surface Debris Removal With Institutional Controls	Alternative 4 Limited Soil Removal to 3.5 Feet and Backfill with Imported Soil	Alternative 5 Clean Closure
Long-Term Effectiveness					
• Magnitude of Residual Risk	Does not achieve RAO's. Human health risks from direct contact with lead impacted soil insignificant. Areas with highest concentrations of metals pose marginal risk to ecological receptors.	Alternative 2 does not achieve RAO's or improve long-term residual risk compared to No Action (Alternative 1).	Alternative 3 does not achieve RAO's or improve long-term residual risk compared Alternatives 1 or 2.	Alternative 4 achieves RAOs, reducing potential impact to ecological receptors and human health.	Alternative 5 achieves RAOs, reducing potential impact to ecological receptors and human health.
• Adequacy and Reliability of Response Actions	Not applicable	Land use restrictions reliable.	Land use restrictions reliable.	Site to be graded and restored to surrounding/native conditions following removal actions. Minimal long-term maintenance required. Erosion and drainage control maintenance.	Site to be graded and restored to surrounding/native conditions following removal actions. No long-term maintenance required.
Reduction of Toxicity, Mobility, and Volume (TMV)	None.	None.	Minimal.	Reduces the potential for direct contact with humans and ecological receptors by removing waste to a depth of 3.5 feet below ground surface.	Reduces the potential for direct contact with humans and ecological receptors by removing waste and lead and aluminum impacted soil at concentrations greater than or equal to RAOs goals.
Short-Term Effectiveness	Not effective, does not achieve RAOs.	Minimal hazards to construction workers during implementation of institutional controls (installing signs).	Minimal hazards to construction workers during implementation of Alternative 3. (installing signs, removing debris). However, risk involves locating and removing potential UXO.	Moderate hazards to construction workers during site work activities. However, risk involves locating and removing potential UXO, working with heavy equipment and around excavations, and airborne lead particulates. Ecological receptors may be relocated.	Moderate hazards to construction workers during site work activities. However, risk involves locating and removing potential UXO, working with heavy equipment and around excavations, and airborne lead particulates. Ecological receptors may be relocated.

TABLE 11-2

DETAILED ANALYSIS OF ALTERNATIVES FOR SITE FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER, FORT IRWIN

Name of Alternative	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Surface Debris Removal With Institutional Controls	Alternative 4 Limited Soil Removal to 3.5 Feet and Backfill with Imported Soil	Alternative 5 Clean Closure
Implementability					
• Technical Feasibility	Implementable.	No closure activities undertaken. Signage and deed restrictions easy to implement.	No closure activities undertaken. Signage, deed restrictions, and removal of surface debris, easy to implement.	Removal of waste to a depth of 3.5 feet and the placement of a soil cover is moderately easy to implement.	Excavation and offsite disposal for waste and lead impacted soil at concentrations greater than or equal to RAOs is moderately easy to implement.
• Availability of Services And Materials	None.	Services for signage installation are readily available.	Services for signage installation and debris removal are readily available.	Services, equipment and materials for excavation and offsite disposal and the installation of an imported soil cover are readily available.	Services, equipment and materials for excavation and offsite disposal are readily available.
• Administrative Feasibility	No administrative difficulties associated.	No administrative difficulties associated with installation of signage or the implementation of deed restrictions.	No administrative difficulties associated with installation of signage and the implementation of deed restrictions or surface debris removal.	No administrative difficulties associated with Alternative 4. Permits and specialized staff required for dust minimization, habitat disturbance. Construction work may be seasonally restricted based on Mojave ground squirrel estivation and reproduction cycles.	No administrative difficulties associated with Alternative 5.

TABLE 11-2

DETAILED ANALYSIS OF ALTERNATIVES FOR SITE FTIR-40 AREA 1.1
NATIONAL TRAINING CENTER, FORT IRWIN

Name of Alternative	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Surface Debris Removal With Institutional Controls	Alternative 4 Limited Soil Removal to 3.5 Feet and Backfill with Imported Soil	Alternative 5 Clean Closure
Cost	See Table N-4 for detailed cost estimate of Alternative 1.	See Table N-5 for detailed cost estimate of Alternative 2.	See Table N-6 for detailed cost estimate of Alternative 3.	See Table N-7 for detailed cost estimate of Alternative 4.	See Table N-8 for detailed cost estimate of Alternative 5.
• Capital Cost	$0	$71,120	$114,945	$652,586	$1,263,452
• Annual O&M Costs	$0	$7,200	$7,200	$10,600	$0
• Five-Year O&M Costs	$9,600	$9,600	$9,600	$9,600	$0
• Five-Year Present Worth	$7,000	$108,000	$152,000	$488,000	$902,802
State Acceptance	Likely to be unacceptable	May be acceptable, state usually requires involvement in land use restrictions	May be acceptable, state usually requires involvement in land use restrictions	Acceptable	Acceptable
Community Acceptance	Likely to be acceptable	Likely to be acceptable	Likely to be acceptable	Acceptable although community may be concerned with disturbance of habitat	Acceptable although community may be concerned with disturbance of habitat

TABLE 12-1

SUMMARY OF RECOMMENDATIONS
FOR SITES FTIR-38 AND FTIR-40
NATIONAL TRAINING CENTER, FORT IRWIN

Site	Recommendation
Site FTIR-38 Area 1	No further action
Site FTIR-38 Area 2	The preferred remedial alternative is Alternative 3 – Soil Removal/Disposal
Site FTIR-40 Area 1.1	The preferred remedial alternative is Alternative 4 –Limited Soil Removal to 3.5 Feet and Backfill with Imported Soil
Sites FTIR-40 Area 2	No further action